



## **OPERATION AND MAINTENANCE MANUAL**

## **SELF READING ELECTRONIC DOSIMETER**

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# **Operation and Maintenance Manual**

## **Self Reading Electronic Dosimeter**

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## 1. ABOUT THIS MANUAL

This manual covers SAIC's diverse line of Self Reading Electronic Dosimeters. The latest addition to this line is the *i*-series. These models incorporate an Idle Mode which considerably increases battery life. The PD-3*i* is the core model. It is available in a number of variations, all of which share similar electronic circuitry and radiation measurement characteristics. **Throughout this manual, all references to PD-3*i* and Self Reading Electronic Dosimeters will pertain to all models covered, unless stated otherwise.**

### 1.1 Models Covered

The five variations, available in any combination, of SAIC's Self Reading Electronic Dosimeters are:

- Idle Mode - Provides an electronic shut-down mode, enabled by a PDR-1™ Reader, at which time there is virtually no drain on the battery. This is a feature of all *i*-series dosimeters, identified by an “*i*” in their model number.
- SI Units - Displays in units of Sieverts rather than R (1 Sv = 100 R), otherwise identical to corresponding R models. These units are identified by a “2” in their model number, i.e., PD-2*i*, PD-12*i*, etc.
- Pushbutton Adjustable - Stand-alone operation by allowing setting of alarm levels and options through activation of the mode and backlight buttons. The numeric portion of the model number for these units is “10” or “12”.
- Extremity Probe - These units have an external, rather than internal, Geiger Mueller tube, which is connected to the dosimeter with a flexible cable. They are identified by an “E” in their model number.
- Pushbutton On-Off Models – The “-S” Series dosimeters are capable of being turned off without removing the battery or using the PDR-1 Reader interface. SAIC “-S” Series dosimeters are equipped with an “ON-OFF” button. Press the “ON” button to activate the dosimeter. Press and hold the “ON-OFF” button for five seconds to turn the dosimeter off.

The unique features of the Pushbutton Adjustable and Extremity Probe models are described in Appendices A, B and C. Figure 1.1-1 lists all models covered in this manual and their unique features.

**Figure 1.1-1**

| MODEL NUMBER | IDLE MODE | SI UNITS | PUSHBUTTON ADJUSTABLE | EXTREMITY PROBE | ON-OFF SWITCH |
|--------------|-----------|----------|-----------------------|-----------------|---------------|
| PD-3i        | •         |          |                       |                 |               |
| PD-3i-S      | •         |          |                       |                 | •             |
| PD-3         |           |          |                       |                 |               |
| PDE-3i       | •         |          |                       | •               |               |
| PDE-3        |           |          |                       | •               |               |
| PD-10i       | •         |          | •                     |                 |               |
| PD-10        |           |          | •                     |                 |               |
| PDE-10i      | •         |          | •                     | •               |               |
| PDE-10       |           |          | •                     | •               |               |
| PD-2i        | •         | •        |                       |                 |               |
| PD-2i-S      | •         | •        |                       |                 | •             |
| PD-2         |           | •        |                       |                 |               |
| PDE-2i       | •         | •        |                       | •               |               |
| PDE-2        |           | •        |                       | •               |               |
| PD-12i       |           | •        | •                     |                 |               |
| PD-12        | •         | •        | •                     |                 |               |
| PDE-12i      | •         | •        | •                     | •               |               |
| PDE-12       |           | •        | •                     | •               |               |



# 1. INTRODUCTION

The PD-3i<sup>TM</sup><sup>1</sup> Self Reading Electronic Dosimeter offers personal dose and dose rate monitoring in a rugged, lightweight package. The PD-3i measures photon radiations (gamma and x-rays) and provides dose measurement, dose rate measurement, chirp and stay-time alarms. The system offers the user improved monitoring while reducing interference and annoyance of the larger, more cumbersome electronic dosimeters currently available. Features such as long battery life, long calibration life, easy computer interface and dose history simplify the working procedures of the health physicists who oversee dosimetry management programs. With appropriate calibration, strong correlation between a PD-3i and a thermoluminescence dosimeter (TLD) can be established.

## 1.1 PD-3i Highlights

| FEATURE                                                                                 | BENEFIT                                                                                                    |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| GM Tube with patented implementation                                                    | <i>Superior accuracy and inherent protection from RFI, micophonics and temperature changes</i>             |
| Full Featured including Dose Alarms, Rate Alarm, Chirp and Stay Time Alarms             | <i>Improved ALARA performance is possible</i>                                                              |
| Lost Alarm                                                                              | <i>Helps locate missing unit and reduces inventory erosion</i>                                             |
| Extended dose range from 0 $\mu$ R to 999R [0 Sv to 10 Sv]                              | <i>Provides sensitivity to record background radiation and yet could replace three pocket ion chambers</i> |
| Automatic ranging LCD display                                                           | <i>Informative and easy to read</i>                                                                        |
| Backlight with 6 s dwell                                                                | <i>Reading in low-light situations</i>                                                                     |
| Use of any standard AA size battery                                                     | <i>Safe, available, and inexpensive</i>                                                                    |
| Low power usage                                                                         | <i>Long battery life (typically &gt; 750 hours continuous operation with 1.5V AA alkaline)</i>             |
| Idle Mode (i-Series only)                                                               | <i>Allows shut down of unit when not in use, considerably increasing battery life</i>                      |
| Protected reset accessed only via the computer interface (Except Pushbutton Adjustable) | <i>Protects against inadvertent loss of dosimetry data</i>                                                 |
| Very rugged construction using a proven impact resistant plastic case with clip         | <i>Significantly increases the useful life of the dosimeter</i>                                            |
| Built-in test continuously monitors operability of radiation sensor                     | <i>Protects against exposure resulting from inadvertent use of a defective dosimeter</i>                   |

<sup>1</sup> All references to PD-3i will pertain to all models covered, unless stated otherwise.

## 1.2 The PD-3i

The PD-3i Personal Dosimeter is shown in Figure 1.2-1. The custom display, shown in the top view, contains many features. These include:

- DOSE Icon  
Flashes when the accumulated dose has exceeded the Dose Alarm set point.
- RATE Icon  
Flashes when the calculated dose rate is in excess of the Dose Rate Alarm set point.
- BATTERY Icon  
Flashes to warn of a low battery.
- GAMMA Icon  
Flashes each time a pulse is detected by the Geiger-Mueller tube (one pulse is approximately 1.45  $\mu\text{R}$ ).  
[14.5 nSv]
- Numeric Display  
Provides the three significant digits and is automatic ranging.
- Units Display  
Automatically provides the correct units in either  $\mu\text{R}$ ,  $\text{mR}$ ,  $\text{R}$ ,  $\mu\text{R}/\text{h}$ ,  $\text{mR}/\text{h}$ ,  $\text{R}/\text{h}$  or  $\text{m}$  [ $\mu\text{Sv}$ ,  $\text{mSv}$ ,  $\text{Sv}$ ,  $\mu\text{Sv}/\text{h}$ ,  $\text{mSv}/\text{h}$ ,  $\text{Sv}/\text{h}$  or  $\text{m}$ ]

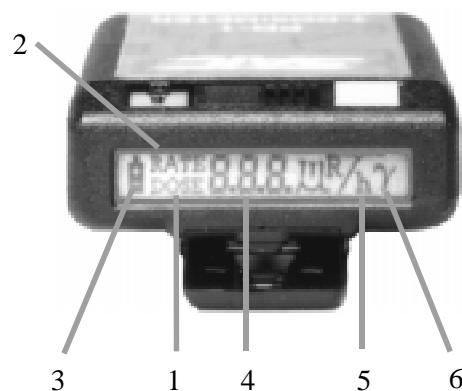
On the front of the PD-3i are four significant features as shown in the Front View of Figure 1.2-1. The Mode button controls the display of the PD-3i. Each of the modes are discussed in detail in Section 2.2. The audible alarms emanate from the sound port. The Backlight/Run button activates the display light to allow for reading the PD-3i display under subdued lighting conditions. It is also used to bring the unit out of Idle Mode for *i*-series models. The Communications Surface provides the interface between the PD-3i and the PDR-1™ Dosimeter Reader.

The belt clip can be removed by pressing the belt clip release button (see Figure 1.2-1, Side View) and sliding the belt clip towards the top of the case.

The effective center of detection for the GM Tube, is marked on the side of the PD-3i case by a “+” symbol as shown. The depth of the center of detection is located by the left edge of the labels when viewed from the back of the PD-3i.

See Figure 1.2-1, Back View.

Figure 1.2-1: The PD-3i™ Personal Dosimeter



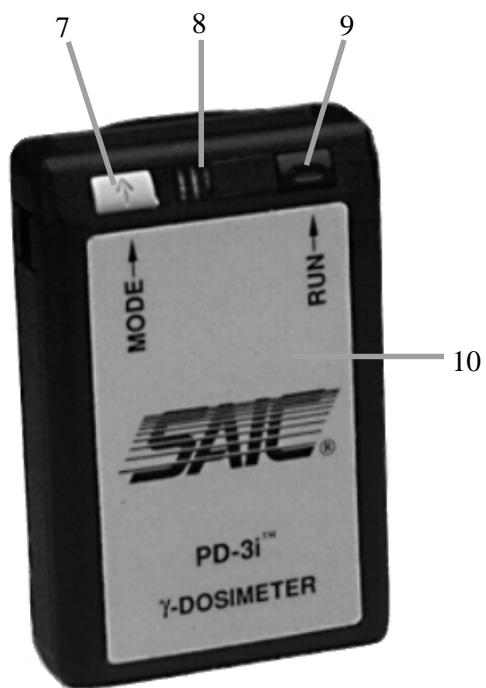
**Top View:**

1. DOSE Icon
2. RATE Icon
3. Battery Icon
4. Numeric Display
5. Units Display
6. Gamma Icon



**Side View:**

11. Belt Clip Release Button
12. GM Tube Center Mark

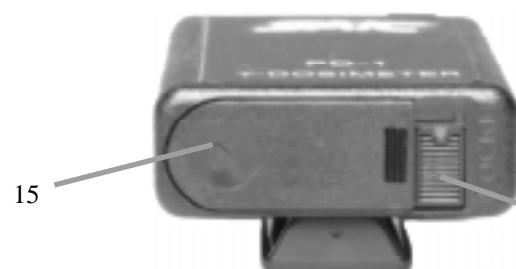


**Front View:**

7. Mode Button
8. Sound Port
9. Backlight Button
10. Communications Surface

**Back View:**

13. Belt Clip
14. GM Tube Center Line (left edge of label)



**Bottom View:**

15. Battery Compartment Cover
16. Battery Compartment Lock



## 2. OPERATION

### 2.1 Battery Installation

The PD-3i<sup>TM</sup><sup>1</sup> is activated by installing a single AA battery. It will initially be in the Idle Mode, at which time all circuitry is shut down and there is virtually no drain on the battery. To wake up the PD-3i and initiate operation as a dosimeter, simply depress the Backlight/Run button and the firmware revision number will appear on the display. Non-*i*-Series models will power up as operating dosimeters immediately following the installation of a battery. If the firmware revision number does not display first, then the unit has version F.03.

The battery compartment is accessed through the bottom of the unit (see Figure 2.1-1). (1) Slide the battery compartment lock to the unlocked position. (2) Slide the battery compartment cover off. If the dosimeter battery cover is supplied with a locking screw (optional feature), it must be removed by using an appropriate Allen wrench.

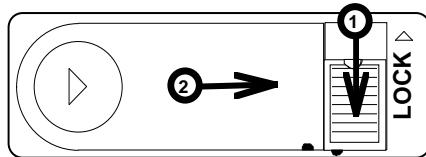


Figure 2.1-1 Opening the battery compartment

Install the battery's **positive terminal first** as shown in Figure 2.1-2. (1) Close the case by aligning the dots on the battery compartment cover and the case, (2) press down and slide the cover to its original position, as shown in Figure 2.1-3. (3) Slide the battery compartment lock to the locked position.

**CAUTION: IF THE BATTERY IS REMOVED, WAIT AT LEAST TEN SECONDS BEFORE REINSERTING A BATTERY.**

The user should wait at least ten seconds before reinserting a battery to allow power-up circuitry to initialize itself. Removing the battery and waiting the necessary 10 seconds will return the PD-3i to a normal quiescent state.

---

<sup>1</sup> All references to PD-3i will pertain to all models covered, unless stated otherwise.

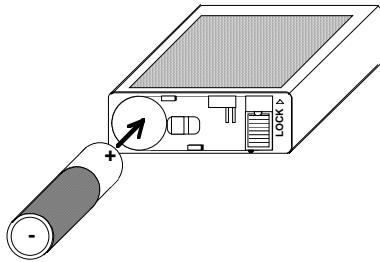


Figure 2.1-2 Installing the battery

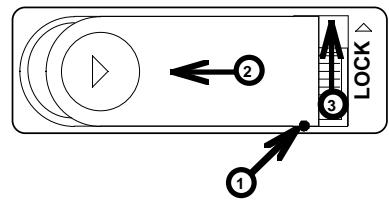


Figure 2.1-3 Closing the battery compartment

## 2.2 Operating Modes

There are four possible modes of operation. The Dose Rate and Stay Time modes are optional. The modes, in the order they appear, are: (1) Dose; (2) Dose Rate; (3) Stay-Time and (4) Confirmation. They appear on the display by pressing the Mode button (see Figure 1.2-1, Front View). When the Mode button is pressed, the audio alarm is beeped and the LCD is momentarily blanked. The non-display modes are Idle (*i*-Series only), Chirp, Input/ Output, and Out (*i*-Series only).

### 2.2.1 Dose Mode

The display shows the accumulated dose since the last reset. The dose is shown in a three digit floating point display in units of  $\mu\text{R}$ ,  $\text{mR}$ , or  $\text{R}$  [ $\mu\text{Sv}$ ,  $\text{mSv}$ , or  $\text{Sv}$ ] with automatic ranging. A user set option allows the unit to display only  $\text{mR}$  and  $\text{R}$  [ $\text{mSv}$ ,  $\text{Sv}$ ] units.

### 2.2.2 Dose Rate Mode

The PD-3i is not designed to be a survey instrument. Nonetheless, it measures dose rate from background to 500  $\text{R}/\text{h} \pm 15\%$  or 20  $\mu\text{R}/\text{h}$  [ $5 \text{ Sv}/\text{h} \pm 15\%$  or 0.2  $\mu\text{Sv}/\text{h}$ ], whichever is greater. The dose rate is constantly being calculated, even when the PD-3i is in other display modes. As with dose, dose rate is shown in a three digit floating point display. Units are  $\mu\text{R}/\text{h}$ ,  $\text{mR}/\text{h}$ , or  $\text{R}/\text{h}$  [ $\mu\text{Sv}/\text{h}$ ,  $\text{mSv}/\text{h}$ , or  $\text{Sv}/\text{h}$ ] with automatic ranging. For complete dose rate calculation information, see Appendix D, page D-20.

### 2.2.3 Stay-Time Mode

Stay-Time mode displays the contents of a count down timer. Stay-Time Alarms are controlled through the push buttons or through the PDR-1 Dosimeter Reader. Stay-Time and Stay-Time-Warning alarms are available. Each alarm can be set from 0.1 minutes to 109 hours (6553 minutes). The display will indicate 999 m for remaining stay times in excess of 999 m. The display shows how many minutes remain until the final stay-time alarm will be annunciated.

#### 2.2.4 Confirmation Mode

For Pushbutton Adjustable models, refer to Appendix A for the operation of the Confirmation Mode.

The Confirmation Mode displays alarm settings and a test pattern for the display. Upon entering Confirmation mode, the dosimeter will first display the current Dose Alarm setting. Next, the Dose Rate Alarm setting will automatically be displayed, followed by Stay-Time and Chirp Increment. Finally, a test pattern is presented. The test pattern displays all segments of the LCD. A RATE icon flashing during the test indicates that the Audio Rate Alarm is disabled. Once the display test is complete, the dosimeter will automatically return to the Dose Mode. Pressing the Mode button at any time while in Confirmation Mode will immediately return the unit to Dose Mode.

If the backlight switch is depressed when confirmation mode is entered, the Audio Alarm patterns are annunciated while the Alarm Limits are being displayed. The annunciated alarms are as follows (see Section 2.9):

| <u>Display:</u> | <u>Audio Annunciation Presented:</u>                                                                                                                    |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| •DOSE ALARM     | 4 cycles of DOSE/TIME-Warning alarm,<br>4 cycles of DOSE/TIME alarm                                                                                     |
| •RATE ALARM     | 8 cycles of RATE alarm                                                                                                                                  |
| •STAY-TIME      | 4 cycles of DOSE/TIME-Warning alarm,<br>4 cycles of DOSE/TIME                                                                                           |
| •CHIRP INC.     | 8 Chirps                                                                                                                                                |
| •LCD Display    | 4 cycles of PDE Probe Disconnect alarm,<br>4 cycles of High Voltage Power Supply Failed alarm, 4 cycles of LOST alarm,<br>4 cycles of GMT Failed alarm. |

If the Mode Button is pushed again while the PD-3i is still in Confirmation Mode, the unit returns immediately to Dose Mode.

If a Time, Dose, or Rate Alarm becomes active, Confirmation Mode execution is aborted and the mode is changed to display the quantity responsible for the alarm.

#### 2.2.5 Input/Output Mode

Input/Output Mode cannot be accessed by the Mode Button. This mode allows bi-directional communication between a PDR-1 reader and the dosimeter. It is used for viewing and setting alarm levels and options. It can

only be accessed by the reader. While in this mode, the display will show I-O.

#### 2.2.6 *Idle Mode*

This mode is available with *i*-Series dosimeters only. When in the Idle Mode, all circuitry will shut down. The display will be blank and no dose will be accumulated. There is virtually no drain on the battery in this state.

The dosimeter will begin operation in the Idle Mode whenever a battery is installed. From that point on, the Idle Mode may be entered through a PDR-1 Reader or by using the correct pushbuttons on the pushbutton adjustable models. (See Appendix A.) This can be accomplished by pushing the PDR-1's Dose Reset button or by sending the appropriate command to the Reader via an application program running on a PC.

To come out of Idle Mode and begin operation as a Self Reading Electronic Dosimeter, simply depress the Run/On-Off button. The dosimeter will first display its firmware revision number. It will then go directly to Dose Display Mode and sound a single power-up chirp.

#### 2.2.7 *Chirp Mode*

Chirp Mode is an audio mode. It operates continuously regardless of the current display mode, providing it is enabled and no audio alarm is currently unacknowledged.

A chirper sounds a brief tone, or "chirp", each time a specified amount of dose is accumulated. The chirp increment can be set at any dose increment from 0  $\mu$ R to 50 mR [0  $\mu$ Sv to 0.50 mSv]. For example, if the chirp increment is set to 20 mR [0.2 mSv], then each time the dosimeter accumulates 20 mR [0.2 mSv] of dose, no matter what the rate, a chirp will sound. As you move to higher radiation fields, the time between chirps will decrease. This feature will give you an audible indication that you are moving into a higher rate field, even though you may not have reached any of your alarm limits. The Chirp Mode may be disabled by setting the chirp increment to zero. The Chirp rate will increase linearly with the dose rate until the rate of one chirp every 0.75 seconds is reached. For non-*i*-series dosimeters, this is the maximum chirp rate achievable.

##### 2.2.7.1 *i*-Series Enhancements

The *i*-Series dosimeter incorporates a feature which provides Chirp Mode indication of dose rates beyond the linearly represented region. Once the Chirp rate has reached one chirp every

0.75 seconds, the number of chirps per 0.75 second interval begins to increase as the log (base 2) of the dose rate. In other words, after 1 chirp/0.75 second interval is reached, another chirp is added each time the dose rate doubles. The maximum Chirp Rate for *i*-Series dosimeters is six chirps every 0.75 seconds.

The maximum dose rate represented by the Chirp Mode is a function of Chirp Increment. As an example, for the short Chirp Increment of 10  $\mu$ R [0.1  $\mu$ Sv], the linear Chirp representation region would end at a dose rate of 48 mR/h [480  $\mu$ Sv]. The logarithmic region would extend out to 1.54 R/h [15.4 mSv/h] before the Chirp Rate saturated.

#### 2.2.8 *Out Mode*

This mode is available with *i*-Series dosimeters only. This mode can only be initiated and terminated with a PDR-1 Reader. The Out Mode can be used to provide a visual indication of the current status of a PD-3i. It can assist in assuring that proper “log in” and “log out” procedures are followed in an access control environment.

When Out Mode is enabled, typically during a “log out” operation, the PD-3i will display “Out”. In this state the dosimeter will operate normally in every way except that the display will always read “Out”. It will continue to accumulate dose and any enabled audio alarms can still be acknowledged. When Out Mode is terminated, typically during a “log in” operation, the display will return to normal numeric display.

### 2.3 **Dose History**

All SAIC *i*-Series dosimeters are capable of retaining up to 223 data points of dose history. The data points are stored in EEPROM so they will not be lost in the event of power loss. The time interval between data points is defined through the PDR-1. The time interval may range from 0.1 minutes to 109 hours (6553 minutes). The Dose History buffer can be set to be either circular or linear.

The user can select whether the dosimeter retains the most recent 223 data points (circular) or the first 223 data points (linear). If the user elects to retain the most recent 223 data points, as the EEPROM registers become full, the register will overwrite the oldest data. A detailed description of data storage for dose history is presented in Appendix G.

## 2.4 Underwater Case

The underwater dosimeter housing is designed to withstand depths of up to 350 feet. The lightweight housing keeps SAIC pocket sized dosimeters dry, and can be modified to hold a combination of dosimeter and TLD badge.

SAIC also offers cost effective methods for underwater surveys and worker protection using components of the RadStar™ System.

## 2.5 Alarms

The PD-3i has audible and visual alarms which can be defined by the user through any PD Series Reader, or by using the pushbuttons for pushbutton adjustable models.

### 2.5.1 *Dose Alarm*

When the total accumulated dose exceeds the Dose Alarm set point, the PD-3i will sound an audible alarm. A user-set option determines whether this alarm can be acknowledged by pressing the Mode button. In addition, the DOSE icon will flash on the display and will continue to flash until the PD-3i is reset on a Reader or by removal of the battery.

### 2.5.2 *Dose Warning Alarm*

SAIC *i*-Series dosimeters include a Dose Warning Alarm. This alarm may be used to provide workers with an early warning that they are approaching their dose limit – allowing them time to leave the work area before their exposure limit is reached. The Dose Warning Alarm feature may be disabled by setting the Dose Warning Alarm value equal to the Dose Alarm value. The Dose Warning Alarm may be set anywhere in the range from 0.00  $\mu$ R to 999 R [0  $\mu$ Sv to 9.99 Sv]. The Dose Warning Alarm is acknowledged and silenced by pressing the mode button.

### 2.5.3 *Dose Rate Alarm*

The Dose Rate Alarm is activated when the user is in a radiation field above the alarm limit. An audible alarm will sound and the RATE icon will flash on the display. The alarm will continue to sound and the icon will continue to flash until the PD-3i is removed from the radiation field. Dose Rate Alarm may be disabled via a user-set option.

### 2.5.4 *Lost Alarm*

The Lost Alarm feature may be activated to assist in finding lost dosimeters and rendering stolen dosimeters unusable. With the Lost Alarm feature, the user can define a time interval which starts with the most recent PDR-1 transaction. When the interval expires, the dosimeter blanks its display and initiates the audio “Lost” alarm. The setting can range from 0.1 minutes to 109 hours (6553 minutes).

#### 2.5.5 *Stay-Time Alarm*

The Stay-Time Alarms feature may be activated to control working time intervals. Stay-Time and Stay-Time Warning alarms are available. Each alarm can be set from 0.1 minutes to 109 hours (6553 minutes). The display will indicate 999 m for remaining stay times in excess of 999 m.

Stay-time is presented in a count-down manner so workers know how much time is left to complete a task. When the Stay-time reaches 00.0 m, the display switches to the Stay-Time Mode and the alarm sounds. A user-set option determines whether this alarm may be acknowledged by pressing the mode button. Stay-times may range from 0.1 minutes to 109 hours (6553 minutes). Stay-time may be disabled via another user-set option.

#### 2.5.6 *Stay-Time-Warning Alarm*

The Stay-Time-Warning Alarm provides users an advanced indication of the approaching time limit for a job. The Stay-Time-Warning Alarm feature may be disabled by setting the warning alarm time to zero so that it coincides with the Stay-Time Alarm. The Stay-Time-Warning Alarm is acknowledged by pressing the Mode button. Stay-Time-Warning Alarms may range from 0.1 minutes to 109 hours (6553 minutes). Note that a Stay-Time Warning Alarm value of 10 minutes will cause the alarm to activate when there are 10 minutes of remaining stay-time (**not** 10 minutes after the stay timer is re-initialized).

#### 2.5.7 *Sensor Failure Alarm*

The “GMT Alarm” is the time interval (in units of 1024 seconds) after which the dosimeter initiates a sensor failed alarm if no GMT counts are detected. From one standpoint, this value should be set low to minimize the amount of time that a failed GMT goes undetected. However, lower values for GMT Alarm increase the false alarm rate. For example, the GMT of a PD-3i generates about 35 counts/hour at background. The probability that it won’t generate a count in 1024 seconds is  $\exp(-35 \cdot 1024 / 3600) = 0.0000475$ . Therefore, the probability that it won’t generate a false alarm in 1024 seconds is  $(1 - 0.0000475) = 0.9999525$ , and the probability that it won’t generate a false alarm in one day is

$0.9999525^{(24 \cdot 3600/1024)} \approx 0.9960$ . Thus, there is about a 0.4% probability that a false alarm will be generated during any 24 hour period of operation (if GMT Alarm = 1). This false alarm rate drastically drops if GMT Alarm is set to 2, 3, 4 or 5. When the PD-3i is used in radiation fields of  $100 \mu\text{R/h}$  or more, the probability for false alarms drops to essentially zero.

#### 2.5.8 *General*

Dose and Stay-Time alarms are acknowledged by pressing the Mode button. This action silences the audio, which cannot become active again until the dosimeter is rearmed by the PDR-1 Reader via RESET, or by interruption of supply power. Pushbutton Adjustable models may also be rearmed by entering the Set Alarm Mode. The Stay-Time and Dose Audio alarms are not acknowledgeable unless the acknowledge option has been enabled.

Acknowledgment of a Rate Alarm by pressing the Mode button does not terminate the audio, but only advances the Display Mode, thus allowing the user to see Dose and Time values while the Rate alarm is still active. The Rate Alarm is rearmed each time the Rate value makes a negative transition across the Rate Alarm Level. If multiple alarms are active when the Mode button is pushed, disarming is performed in the following order: Rate, Stay-Time-Warning, Dose Warning, Stay-Time, and Dose. A Mode button closure which results in the disarming of any alarm except the Rate Alarm will not advance the PD-3i display mode. Also, the Dose/Time-Warning alarms are automatically disarmed when the Dose/Time alarms become active.

### 2.6 Low Battery Operation

The battery voltage is tested every 0.75 seconds and the international battery icon flashes if it is below the preset threshold (1.25 V for *i*-Series, 1.28V for all others). After 32 consecutive low voltage test results, the icon becomes solid and the Low Battery Run Time countdown timer is started.

The Low Battery timer feature provides an orderly power down of the PD-3i after a low battery condition is detected and eliminates the possibility of the dosimeter attempting to operate from marginal supply voltages. The timer may be preset to any time interval in the range from 0 to 39 hours. The Battery icon will be solid while the countdown timer is active. When the timer expires, the display is blanked except for active icons (which will always include the Battery icon), and the PD-3i is halted. The icons will be visible until the battery dies completely and the Pushbutton Mode will be inoperative.

If the timer is set to zero, the PD-3i will shut down without warning once the low battery condition is detected. The recommended shut down time is 12 to 24 hours.

It is possible, and indeed common, at lower battery voltages, for the battery icon to flash momentarily and then disappear without initiating the Low Battery timer. For example, if the battery voltage was nearing the low battery threshold level and an audio alarm was annunciated, the extra drain on the battery could pull its voltage below the threshold and the battery icon would begin to flash. If the audio alarm then stopped before 32 consecutive “low” tests, the battery voltage could rise above the threshold and the Low Battery timer would not be initiated.

#### 2.6.1 *i*-Series Enhancements

The *i*-Series dosimeters contain additional features which enhance the user’s ability to track the discharge of the battery. Consider the case of a PD-3i which has entered the low battery condition and therefore initiated its countdown timer. When this unit is commanded to go to Idle Mode, it first saves the current value of the countdown timer in EEPROM. On power-up, the PD-3i will perform the sequence of 32 battery tests. If the battery tests low, as it should if it has not been changed, the PD-3i will start its countdown timer from the value that was saved when entering Idle Mode. Therefore, the programmed value of Low Battery Run Time is applied only to the time that the PD-3i is powered up. Now consider the case when the Low Battery countdown timer has reached zero. Before the PD-3i enters Low Battery Shutdown Mode, it saves the value (zero) of the countdown timer in EEPROM.

When a new battery is installed and the RUN button is pressed to power up the PD-3i, it will perform the usual battery voltage tests. If a low battery has been installed, or if the original battery has been re-installed, the battery will test “low” and the countdown timer will be loaded with the saved value. Since the saved value is zero, the unit will immediately go into Low Battery Shutdown Mode.

Note that in Low Battery Shutdown Mode, only the processor is shut down rather than all the circuitry as in Idle Mode. Pushing the RUN button in Low Battery Shutdown Mode has no effect since the voltage regulator is already operating. The only way to restore normal operation is to install a fresh battery.

To replace the battery, follow the instructions in Section 2.1.

## 2.7 Unexpected Loss of Power/Tamper

(For Pushbutton Adjustable models See Appendix A regarding this feature.)

The PD-3i can alert system operators if a battery has been removed. Should there be an unexpected loss of power (e.g., the battery is removed), all of the information previously in the EEPROM memory is retained. In addition, a flag is set indicating that power was removed. The notification can signal the need for additional instruction to the users. Upon returning the PD-3i to a Reader, and before resetting the dosimeter, the following information can be retrieved:

- peak dose rate measured by the PD-3i while it was powered
- total number of seconds that the dose rate measured by the PD-3i was in excess of the preset Rate Alarm level
- total dose accumulated while the PD-3i was powered
- dose history data – noting each occurrence of power restoration

The PD-3i accomplishes the loss of power notification by changing the way in which the non-volatile EEPROM is updated. The RAM contains the Dose Accumulator as well as registers that hold the current peak dose rate and total time above rate alarm. Under normal operation, these values are copied into EEPROM at the end of every Rate Sampling Interval (RSI) and during all I/O operations. If a power interruption is detected, this EEPROM updating will be inhibited when power is restored. At the next I/O operation, the RAM values will be the post-Tamper data and the EEPROM values will be the pre-Tamper data. Once this initial I/O is complete, the PD-3i returns to normal EEPROM updating.

With *i*-Series dosimeters, the state of the power up with EEPROM Dose option will affect the way the Tamper feature works. If this option is enabled, EEPROM updating will not be inhibited following a power removal.

## **2.8 Backlight**

The PD-3i includes a backlight for use under subdued lighting conditions. A user-selected option allows the backlight either to operate for only as long as the Backlight button is depressed, or to stay on for a pre-set time interval after the button is released. The pre-set backlight duration may be canceled, i.e., the backlight shut off by pressing the backlight button once again.

## **2.9 Self-Test and Alarm Summary**

The PD-3i monitors itself continuously. A number of alarm conditions are brought to the user's attention by a combination of audio and visual alarms. As shown below, the PD-3i generates several distinctly different audio patterns (series of six audio on/off intervals which repeat every 3/4 second) which, in principle, identify the specific type of alarm. To avoid confusion, users may wish to rely on audio only to indicate the existence of some alarm condition which can then be specified by a quick glance at the LCD.

Figure 2.9-1 summarizes the alarm audio and visual patterns.

### Alarm Patterns (Audio On/Off = !-)

| Alarm                      | Audio Pattern           | Display                         |
|----------------------------|-------------------------|---------------------------------|
| <b>DOSE/TIME pre-Alarm</b> | ! - - - - ! - - - -     | Flashing DOSE Icon <sup>1</sup> |
| <b>DOSE/TIME Alarm</b>     | ! - ! - - ! - ! - -     | Flashing DOSE Icon <sup>1</sup> |
| <b>RATE Alarm</b>          | ! - ! - ! - ! - ! - ! - | Flashing RATE Icon              |
| <b>PDE disconnect</b>      | ! ! - ! - ! ! - - ! -   | "n-E" no Ext. GMT <sup>2</sup>  |
| <b>Lost/Stolen</b>         | ! - - ! - - ! - -       | Blank                           |
| <b>No GMT Counts</b>       | ! ! ! - ! - ! ! ! - ! - | "S-F" Sensor Failed             |
| <b>HVPS Failure</b>        | ! ! - ! ! - ! ! - ! ! - | "H-P" High-v Power <sup>3</sup> |
|                            | 0.75s   0.75s           |                                 |

<sup>1</sup> Dose Alarm Only

<sup>2</sup> Extremity Probe Models Only

<sup>3</sup> May flash briefly during powerup

Figure 2.9-1 Alarm Patterns

The speaker output is rated at 80 dBA @ 30 cm continuous tone. Because of the different duty cycles associated with each alarm, the AVERAGE sound level will vary. The Dose Alarm, for instance, has a duty cycle of 33% and so will have an average sound level that is 33% of the continuous tone output, or about 75 dBA @ 30 cm. The Rate Alarm has a 50% duty cycle and will have an average sound level of about 77 dBA @ 30 cm. This information is provided in case the audio alarm level is verified with an inexpensive averaging sound meter. The human ear responds to the instantaneous sound level, which is approximately 80 dBA @ 30 cm in all cases.

The alarms are listed in order of increasing priority in Figure 2.9-1 such that the HVPS alarm would supersede any of the other alarms. During a Lost/Stolen Alarm, all icons, except perhaps the battery icon, are blanked. Except for Push-button Adjustable models, all the alarms are sequentially annunciated if the Back-light button is depressed when Confirmation Mode is selected with the MODE Pushbutton.

### 2.9.1 *i*-Series Dosimeters Displayed Failure Mode

SAIC *i*-Series dosimeters have the ability to display and audibly annunciate two distinct failure modes in addition to the low battery warnings previously explained.

#### Dosimeter Displays **S-F**:

The first of these displayed/annunciated failure modes indicates that the sensor or internal Geiger Mueller Detector has failed, i.e., no GMT counts detected. The diagnostics for sensor failure (**S-F**) is based upon the maximum RSI (rate sampling interval) of 17 minutes or 1020 seconds without a count being detected. Typically, this 1020 second interval is multiplied by a factor (factory default value is 2) to increase the maximum time without a detected count to 2040 seconds. This factor may be reprogrammed only via the J-6389/PD dosimeter reader. The **S-F** display is accompanied by a unique alarm sound. (See Figure 2.9.1 Alarm Patterns).

#### Dosimeter Displays **H-P**

When displayed and annunciated, **H-P** indicates that the High Voltage Power Supply of the PD-3i has failed to maintain 5.0 VDC as required. The **H-P** display is accompanied by a unique alarm sound. (See Figure 2.9.1 Alarm Patterns).

## **3. MAINTENANCE**

### **3.1 Battery Requirements**

SAIC's PD-3i<sup>TM</sup><sup>1</sup> can operate on any standard AA battery which sources current between 1.25 and 3.9V. For availability, waste disposal, discharge characteristics, and cost reasons, we recommend using standard alkaline batteries. The dosimeter responds fully within the operating specifications over the useful range of the battery voltage. The operating life for SAIC's PD-3i is greater than 750 hours in a 10 mrem/h field using alkaline batteries. It is greater than 1000 hours in a 10 mrem/h field using lithium batteries. The operating life for SAIC's PD-3i is greater than 200 hours in a 10 mrem/h field using NiCad batteries. SAIC's PD-3i has a minimum operating life of one day (24 hours) upon indication of low battery for alkaline batteries.

Since the PD-3i draws virtually no battery current in Idle Mode, the operating life is interpreted as the cumulative time during which the unit is operating as a dosimeter.

### **3.2 Cleaning**

The PD-3i is not immersion proof. Should it be necessary, the PD-3i may be wiped down with a damp cloth.

### **3.3 Replaceable Parts**

While your new PD-3i should provide you with years of service, replacement parts are available. An exploded view of the PD-3i showing the placement of user replaceable components and parts list are shown in Appendix D. The case of the PD-3i is fastened with two 5/64 inch Allen head screws.

Since the PD-3i circuit boards are produced using the latest in surface mount technology, none of the components are replaceable by the user without a properly equipped surface mount repair station. However, many of these components are replaceable if the circuit board is returned to the factory.

---

<sup>1</sup> All references to PD-3i will pertain to all models covered, unless stated otherwise.



## 4. FACTORY DEFAULT SETTINGS

### 4.1 Default Alarm Set Points

The PD-3i<sup>TM</sup><sup>1</sup> is delivered fully calibrated with default alarm settings as shown in Figure 4.1-1. Different alarm settings can be set by the factory or through the PDR-1<sup>TM</sup> Reader.

| PD-3i/PD-2i Default Settings               |                                                   |
|--------------------------------------------|---------------------------------------------------|
| INFORMATION                                | FACTORY DEFAULT                                   |
| <b>SETTINGS:</b>                           |                                                   |
| Unit Serial Number                         | Factory Set ONLY                                  |
| User ID (nine digit or six character)      | SAIC                                              |
| Dose Warning Alarm Level                   | 90mR [0.9mSv]                                     |
| Dose Alarm Level                           | 100mR [1mSv]                                      |
| Dose Rate Alarm Level                      | 500mR/h [5mSv/h]                                  |
| Chirp Increment                            | 1mR                                               |
| Stay Time Warning Alarm                    | 15 min                                            |
| Stay Time Alarm                            | 240 min                                           |
| Dose History Interval                      | 5m                                                |
| AutoShut Down Delay                        | 24h                                               |
| Lost Run Time                              | 24h                                               |
| Sensor Failure Alarm (# of 1024s RSIs):    | 2                                                 |
| <b>CALIBRATION:</b>                        |                                                   |
| Calibration Date                           | (Unique to Unit - See Certificate of Calibration) |
| Dose Conversion Factor ( $\mu$ R/count)    | (Unique to Unit - See Certificate of Calibration) |
| Dead Time per Count (usec/count)           | (Unique to Unit - See Certificate of Calibration) |
| Background Correction                      | (Unique to Unit - See Certificate of Calibration) |
| <b>OPTIONS:</b>                            |                                                   |
| Enable/Disable Rate Display Mode           | Enabled                                           |
| Enable/Disable Audio Rate Alarm            | Enabled                                           |
| Rate Mode Change                           | Enabled                                           |
| Stay Mode                                  | Disabled                                          |
| Dose Alarm Acknowledge                     | Enabled                                           |
| Stay -Time Alarm Acknowledge               | Enabled                                           |
| Automatic Shutdown                         | Enabled                                           |
| Backlight 6 second hold                    | Enabled                                           |
| Minimum Units                              | $\mu$ R [ $\mu$ Sv]; $\mu$ R/h [ $\mu$ Sv/h]      |
| Default Rate Reading                       | 20.0 $\mu$ R [0.2 $\mu$ Sv]                       |
| Dose History Buffer                        | Circular                                          |
| Lost Timer                                 | Disabled                                          |
| Control Source ( <i>i</i> -Series only)    | Mode Pushbutton                                   |
| Idle Function ( <i>i</i> -Series only)     | Enabled                                           |
| PowerUp w/EE Dose ( <i>i</i> -Series only) | Disabled                                          |

PD-3i/PD-2i Factory Default Settings 8/95

Figure 4.1-1 PD-3i Factory Default Settings

<sup>1</sup> All references to PD-3i will pertain to all models covered, unless stated otherwise.

## 4.2 User Selected Operating Options

- Rate Display
  - Enables the Rate display. In situations where the health physicist believes the user should not be concerned with dose rate, but only accumulated dose, the rate display can be disabled.
- Rate Audio Alarm
  - Enables the rate audio alarm. Where the unit is being used only for dose tracking, the health physicist may wish to remove the rate alarm feature.
- Rate Change Mode
  - Enables the display to change to the Rate Display when a rate alarm occurs. If enabled, the rate display will occur independent of the Rate Display option setting.
- Stay Time Mode
  - Enables the Stay Time Mode. If disabled, the Stay Time Mode will not appear on the display.
- Dose Alarm Acknowledge
  - Enables the ability to silence the final Dose Alarm by pressing the Mode button. If disabled, the final Dose Alarm cannot be acknowledged and will continue to alarm until the unit is returned to a PDR-1. For Pushbutton Adjustable units this feature is always enabled.
- Stay-Time Acknowledge
  - Enables the ability to silence the final Stay-Time Alarm by pressing the Mode button. If disabled, the final Stay-Time Alarm cannot be acknowledged and will continue to alarm until the unit is returned to a PDR-1. For Pushbutton Adjustable units this feature is always enabled.
- Six Second Backlight Hold
  - Enables the six second dwell of the backlight. This holds the backlight on for six seconds after the Backlight button has been released. Alternatively, if disabled, the backlight will only be activated while the Backlight button is depressed.
- Minimum Units in  $\mu\text{R}$  or  $\text{mR}$  [ $\mu\text{Sv}$  or  $\text{mSv}$ ]
  - Enables the ability for the PD-3i to display dose and dose rate in  $\mu\text{R}$  [ $\mu\text{Sv}$ ] and  $\mu\text{R}/\text{h}$  [ $\mu\text{Sv}/\text{h}$ ]. If disabled, the minimum resolution of the PD-3i™ is 0.01  $\text{mR}$  [0.01  $\text{mSv}$ ].

- Default Rate Reading

The rate reading can be made to default to 20  $\mu\text{R}/\text{h}$  [0.2  $\mu\text{Sv}/\text{h}$ ] in cases where the displayed rate would otherwise be 0  $\mu\text{R}/\text{h}$  [0  $\mu\text{Sv}/\text{h}$ ]. If enabled, 20  $\mu\text{R}/\text{h}$  [0.2  $\mu\text{Sv}/\text{h}$ ] will be displayed when background corrected rates are zero. If disabled, 0  $\mu\text{R}/\text{h}$  [0  $\mu\text{Sv}/\text{h}$ ] will be displayed when the radiation levels are near zero. Recall the accuracy of the PD-3i is  $\pm 15\%$  or  $\pm 20 \mu\text{R}/\text{h}$  from 0  $\mu\text{R}/\text{h}$  to 500  $\text{R}/\text{h}$  [ $\pm 0.2 \mu\text{Sv}/\text{h}$  from 0  $\mu\text{Sv}/\text{h}$  to 5  $\text{Sv}/\text{h}$ ].

- Fractional mR [mSv]  
Units

Enables the ability of the PD-3i to truncate the fractional portion of mR [mSv]. If enabled, the PD-3i will not display in  $\mu\text{R}$  [ $\mu\text{Sv}$ ] units, regardless of the state of the Minimum Units option.

- Dose History Buffer

The Dose History buffer can be selected to be either circular or linear. A circular buffer will always contain the most recently obtained dose values prior to the PD-3i being read on a PDR-1. Dose values contained in a linear buffer are those obtained during the time interval which begins with the most recent reset operation and ends with either 1) the PDR-1 read operation, or 2) filling of the linear buffer.

- Lost Timer

Enabling the lost timer option will cause the dosimeter display to blank and an alarm to sound if the dosimeter is not read on a PDR-1 within the Lost Run Time interval. This alarm condition will also occur when the battery is removed and replaced while this option is enabled. Lost Run Time should be set somewhat longer than the expected job completion time.

- Control Source  
*i*-Series Only

This option allows for the selection of either the Mode pushbutton, or the external serial port, as the control source for the PD-3i. If the external serial port is selected, then an additional option that allows the global disabling of the audio capability of the PD-3i becomes available.

- Idle Function  
*i*-Series Only  
Allows for the disabling of the Idle feature.
- Power Up with  
EEPROM DOSE  
*i*-Series Only  
If enabled, the PD-3i will power up with the currently displayed dose equal to the current accumulated dose stored in EEPROM. If this option is disabled, then the unit will power up with zero as the displayed dose. The Total Dose will be stored in EEPROM and is retrievable through the PDR-1 Reader. (See Section 2.6, *Unexpected Loss of Power/Tamper*.) On Pushbutton Adjustable models this option is always enabled.



**ADDENDUM A TO OPERATION AND MAINTENANCE MANUAL  
SCHEMATICS, DRAWINGS & PARTS LISTS  
FOR SELF READING ELECTRONIC DOSIMETER**

**16701 West Bernardo Drive  
San Diego, CA 92127  
(800) 962-1632  
(619) 646-9831**

**REV 041599**



# APPENDIX A

## PUSHBUTTON ADJUSTABLE MODELS

Although Pushbutton Adjustable models have all the functionality of the PD-10i<sup>TM</sup><sup>1</sup>, they offer the added feature of stand-alone operation. The user has the ability to change alarm levels and enable/disable options by activating the Mode and Backlight/Run buttons. This feature eliminates the need for a computer/reader interface when versatility and low system cost are a primary concern.

Throughout this appendix, all references to PD-10i<sup>TM</sup> will pertain to all Pushbutton Adjustable models, unless stated otherwise. This appendix is limited to a discussion of the features unique to the PD-10i. The main body of this manual covers its general operation. See Appendix B for complete pushbutton programming instructions for the Model PD-10i.

### A.1 Operating Modes

On a PD-10i there are two additional modes which provide for stand-alone operation. The first is the Set Alarm Mode, which allows the user to change alarm levels and options via the PD-10i pushbuttons. On the *i*-Series models, the dosimeter may be sent to Idle Mode as well. The second is the Reset Mode, which allows the user to zero the Dose History by holding down the Mode button until “rES” is written to the LCD (about six seconds).

#### A.1.1 Set Alarm Mode

Set Alarm Mode will be entered if the Backlight/Run button is depressed while attempting to enter Confirmation Mode. From the Stay-Time Mode, or the Rate Mode if Stay-Time is disabled, simply hold the Backlight/Run button down and press the Mode button once. For *i*-Series models, Set Alarm Mode will begin with “IdL” flashing on the display. At this point if the Backlight/Run button is pressed, the unit will immediately go to Idle Mode. If the Mode button is pressed, the display will advance and show the DOSE icon and the current Dose Alarm Level. This will be the initial display when entering Set Alarm Mode on non-*i*-Series models.

At this point the first digit of the Dose Alarm level will flash to indicate a cursor position. Pressing the Backlight/Run button will increment the digit or unit at the cursor. Pressing the Mode button will advance the cursor one position to the next digit or unit. Once the desired alarm level is set, hold down the Mode button and press the Backlight/Run button once to advance the display to Rate Alarm level editing. Similarly, the user can also edit the Stay-Time Alarm level and the Chirp Increment value.

---

<sup>1</sup> All references to the PD-10i will pertain to all pushbutton adjustable models, unless stated otherwise.

Note that the Dose and Stay-Time Warning Alarms are settable via a PDR-1 Reader only. As factory defaults, the Dose Warning is set equal to the Dose Alarm and the Stay-Time Warning is set equal to the Stay-Time Alarm, which effectively disables these warning alarms.

After the Chirp Increment value is set, the user can then edit the option bits. Refer to the following table for the Pushbutton Adjustable options. The display should show a two digit option number followed by the option status — a “1” indicates the option is enabled, a “0” means it is disabled. Pressing the Backlight/Run button will enable/disable the displayed option; pressing the Mode button will advance to the next option.

Once the user is satisfied with the selected options, the Set Alarm Mode is exited by again holding the Mode button down and pressing the Backlight/Run button. When the Set Alarm Mode is exited, all the alarm levels and options will be saved to EEPROM and all the enabled alarms will be rearmed. In addition, all the audio alarm patterns will be annunciated. These alarm patterns can be silenced by pressing the Mode button.

If a Time, Dose, Rate alarm becomes active during Set Alarm Mode, the edit is aborted and the mode is changed to display the quantity responsible for the alarm.

After setting or viewing any alarm levels, use the Confirmation mode to verify the settings are correct.

| <u>Display:</u> | <u>Audio Annunciation Presented:</u>                                                                                                                    |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| •DOSE ALARM     | 4 cycles of DOSE/TIME-Warning alarm,<br>4 cycles of DOSE/TIME alarm                                                                                     |
| •RATE ALARM     | 8 cycles of RATE alarm                                                                                                                                  |
| •STAY-TIME      | 4 cycles of DOSE/TIME-Warning alarm,<br>4 cycles of DOSE/TIME                                                                                           |
| •CHIRP INC.     | 8 Chirps                                                                                                                                                |
| •LCD Display    | 4 cycles of PDE Probe Disconnect alarm,<br>4 cycles of High Voltage Power Supply Failed alarm, 4 cycles of LOST alarm,<br>4 cycles of GMT Failed alarm. |

#### *A.1.2 Reset Mode*

If the Mode button is held down for about six seconds, the PD-10i will display “rES”. The Total Dose, Time Above Rate and the Dose History Buffer will be reset. The existing alarm levels and options will not change. In addition, all enabled alarms will be rearmed.

| PD-10i OPTION MENU INDEX |          |       |                                                               |
|--------------------------|----------|-------|---------------------------------------------------------------|
| OPTION                   | ITEM NO. | VALUE | RESULT                                                        |
| RATE MODE                | 00.      | 0     | Inhibits Rate Mode Display                                    |
|                          |          | 1     | Enables Rate Mode Display                                     |
| AUDIO RATE ALARM         | 01.      | 0     | Inhibits Audio Rate Alarm                                     |
|                          |          | 1     | Enables Audio Rate Alarm                                      |
| CHANGE TO RATE MODE      | 02.      | 0     | Display Mode Does Not Change upon Rate Alarm                  |
|                          |          | 1     | Displays Rate Mode Upon Rate Alarm                            |
| STAY MODE                | 03.      | 0     | Inhibits Stay Time Counter and Stay Mode Display              |
|                          |          | 1     | Enables Stay Time Counter and Stay Mode Display               |
| DOSE ALARM ACKNOWLEDGE†  | 04.      | 0     | Inhibits 2nd (Highest) Audio Dose Alarm Acknowledge           |
|                          |          | 1     | Enables 2nd (Highest) Audio Dose Alarm Acknowledge            |
| STAY TIME ACKNOWLEDGE†   | 05.      | 0     | Inhibits 2nd (Longest) Stay Time Alarm Acknowledge            |
|                          |          | 1     | Enables 2nd (Longest) Stay Time Alarm Acknowledge             |
| LOW BATTERY SHUT DOWN    | 06.      | 0     | Inhibits Automatic Shutdown on Low Battery                    |
|                          |          | 1     | Enables Automatic Shutdown 24 Hours After Low Battery         |
| 6 SECOND BACKLIGHT       | 07.      | 0     | Backlight on Only when Button Depressed                       |
|                          |          | 1     | Backlight Stays on for Six (6) Seconds after Button Depressed |
| RADIATION UNIT           | 10.      | 0     | Smallest Display Unit is mR (Dose) and mR/h (Rate)            |
|                          |          | 1     | Smallest Display Unit is $\mu$ R (Dose) and $\mu$ R/h (Rate)  |
| BACKGROUND DEFAULT       | 11.      | 0     | Background Rate displayed as 0.00 mR/h or 0.00 $\mu$ R/h      |
|                          |          | 1     | Background Rate displayed as 0.02 mR/h or 20.0 $\mu$ R/h      |

† These options always enabled

## **A.2    Unexpected Loss of Power/Tamper**

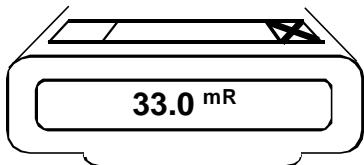
On the Model PD-10i, the Power Up with EEPROM Dose is always enabled. Should there be an interruption of power due to battery removal or entry into Idle Mode, all of the memory previously in the EEPROM of the PD-10i is retained. When power is restored, the display will continue to show accumulated totals until reset, either directly or via the PDR-1 Reader.

## APPENDIX B

### PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

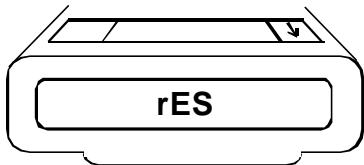
#### I. RESET DOSE MODE

CURRENT DOSE

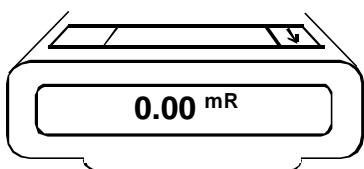


Press and hold indicated button for 5 seconds – alarm sounds continuously.

ENTERING RESET MODE



Release button when “rES” appears in display. Alarm sound stops.



Dose and Stay Time Clock are reset to zero.

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

### II. SET IDLE MODE – WHEN STAY TIME IS ENABLED – Note: When Stay Time is disabled, enter Set Idle Mode from Rate Display Mode.

DOSE DISPLAY



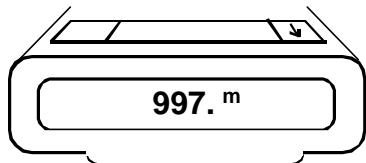
Press indicated button and release.

RATE DISPLAY



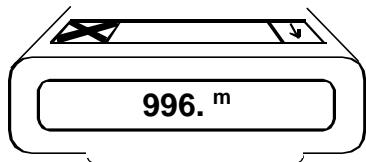
Display switches to Dose Rate Mode. Press indicated button and release.

STAY TIME



Display switches to Stay Time remaining.

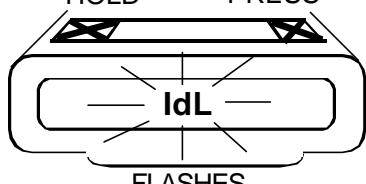
HOLD



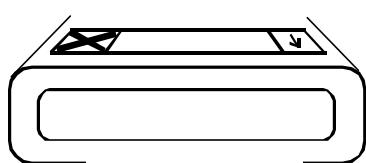
Press and hold indicated button. Display remains in Stay Time Mode.

HOLD

PRESS



While holding indicated button, press other button one time. “**IdL**” flashes on display.

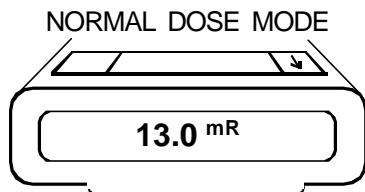


Press indicated button one time. Dosimeter enters Idle Mode. Display goes blank.

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

### III. TO ENTER SET ALARM MODE WHEN STAY TIME IS ENABLED\*

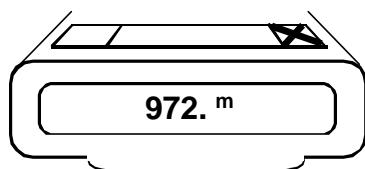
- A. TO SET DOSE ALARM
- B. TO SET DOSE RATE ALARM
- C. TO SET STAY TIME ALARM
- D. TO SET CHIRP RATE
- E. TO SET OPTION BITS



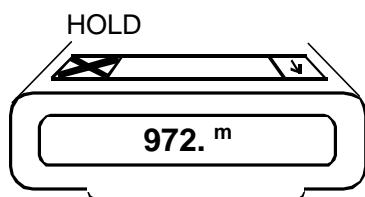
**Step 1:** Start with dosimeter in Normal Dose mode.



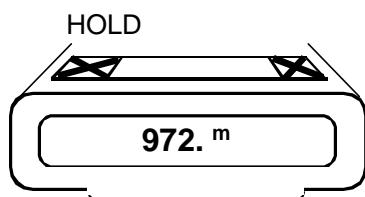
**Step 2:** Press indicated button one time. Dosimeter beeps and displays Dose Rate.



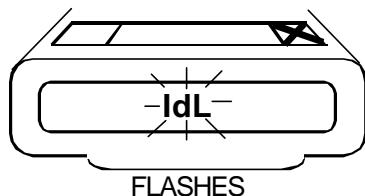
**Step 3:** Press indicated button one time. Dosimeter displays Stay Time remaining.



**Step 4:** Press and hold indicated button. Backlight illuminates. Display remains in Stay Time Mode.



**Step 5:** Continue to hold button as in **Step 4**. While holding, press indicated button one time.



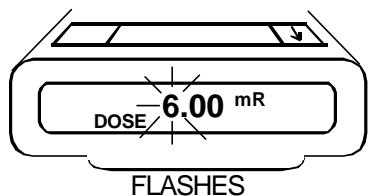
Dosimeter enters Set Alarm Mode. Press indicated button one time.

\* Note: When Stay Time is disabled, enter Set Alarm Mode from Rate Display Mode.

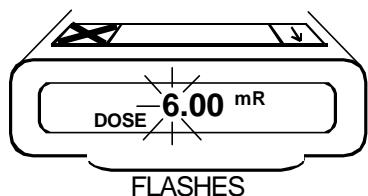
## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

### III. TO ENTER SET ALARM MODE WHEN STAY TIME IS ENABLED

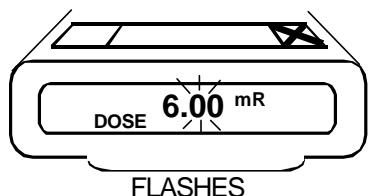
#### A. TO SET DOSE ALARM



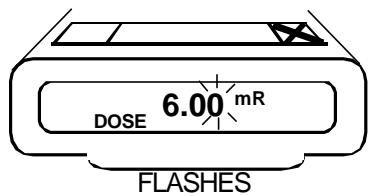
Dosimeter enters Set Dose Alarm Mode. Dose Alarm value is displayed. First digit flashes.



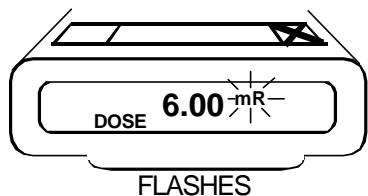
To change flashing digit press indicated button one time. Flashing digit changes and continues to flash.



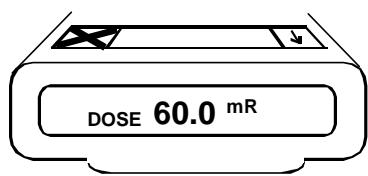
To change to next digit, press indicated button one time. Flashing digit advances to next digit.



To change to next digit, press indicated button one time. Flashing digit advances to next digit and continues to flash.



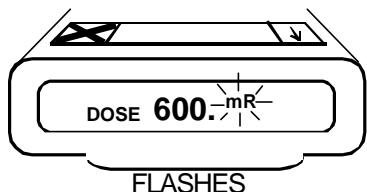
To change position of decimal point and Rad Value, press indicated button one time. Decimal point and Rad value flash.



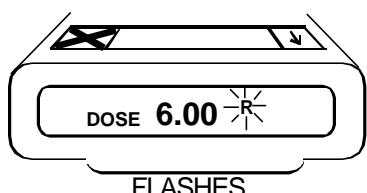
To move decimal point press indicated button one time. Decimal point moves one position to right.

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

### A. TO SET DOSE ALARM (continued)



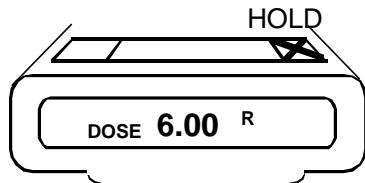
To change Rad value, press indicated button one time until decimal point is to the right of third digit. Rad value flashes.



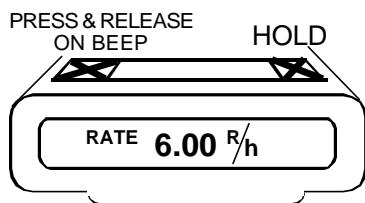
To change Rad value, press indicated button one time. Rad value changes to next value. Decimal point moves to right of first digit.

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

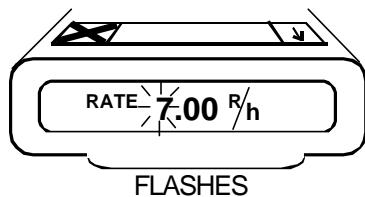
### B. TO SET DOSE RATE ALARM



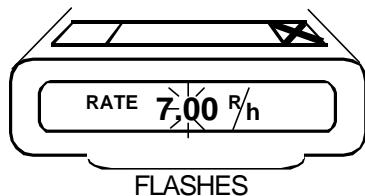
To change to Dose Rate Alarm Set Mode, first press and hold indicated button, then...



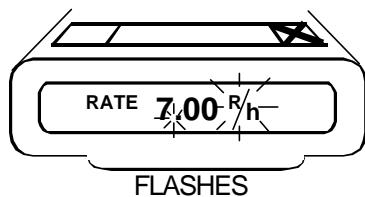
While holding button in previous step, press indicated button one time. Now release both buttons. Dosimeter enters Dose Rate Alarm Set Mode.



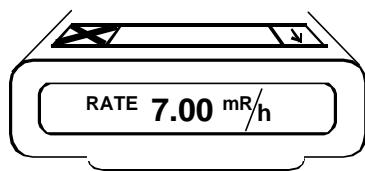
To change flashing digit, press indicated button one time.



To move to next flashing digit, press indicated button one time. Next digit flashes.



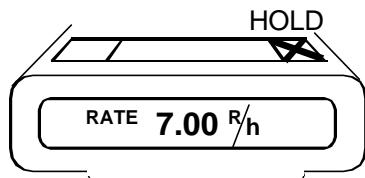
To move decimal point press indicated button until decimal point and Rad value flash, then...



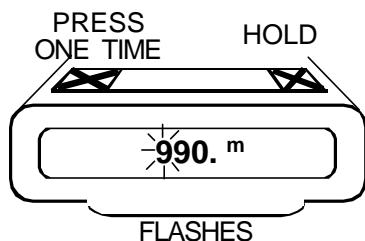
Press indicated button to move decimal point and change the Rad value.

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

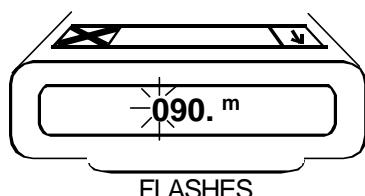
### C. TO SET STAY TIME



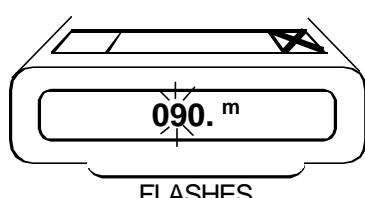
To change to Stay Time Set Mode, press and hold indicated button, then...



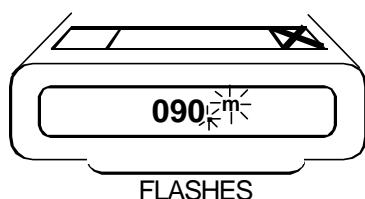
Press indicated button one time (while continuing to hold button from previous step). Dosimeter enters Stay Time Set Mode – first digit flashes.



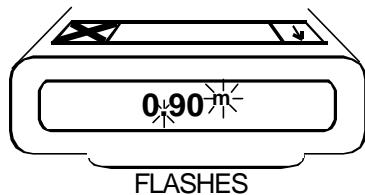
Use indicated button to change flashing digit.



Use indicated button to change to next flashing digit.



Use indicated button to change to flashing decimal point and time value.



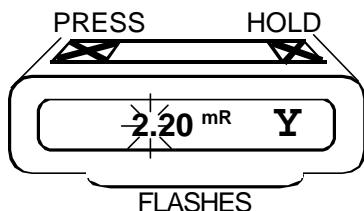
Use indicated button to move decimal point.  
Note: Time value expressed only in minutes "m".

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

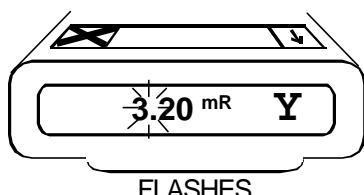
### D. TO SET CHIRP RATE



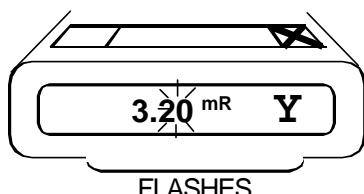
To change to Chirp Rate Set Mode, press and hold indicated button.



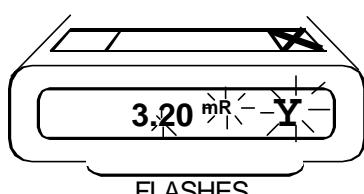
While holding button, press and release indicated button. Display changes to Set Chirp Rate Mode.



To change flashing digit, press indicated button.



To change to next flashing digit, press indicated button.



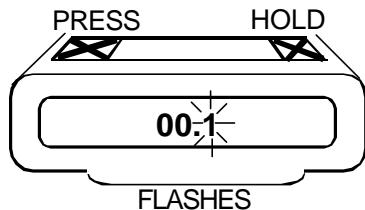
To cause decimal point and Rad unit to flash, press indicated button until decimal point and Rad unit flash.



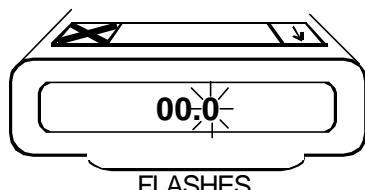
To change position of decimal point and to change Rad unit (microRem or milliRem), press indicated button.

## PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER

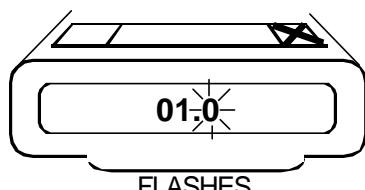
### E. TO SET OPTION BITS



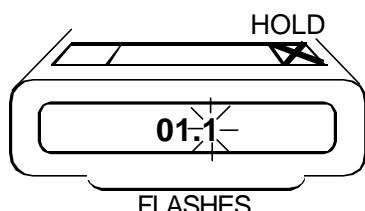
While holding button as directed in previous step, press indicated button one time. Display changes to Option Bit Display. Option Bit **00** is displayed followed by a 1 (enabled) or a 0 (disabled).



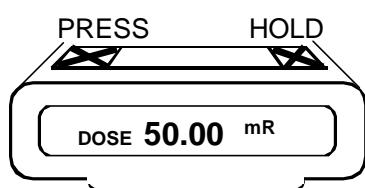
Press indicated button to toggle from 1 (enabled) to 0 (disabled) for Option Bit **00**.



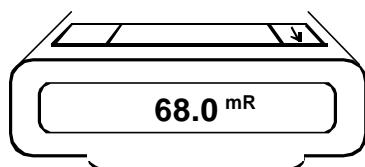
Press indicated button to advance to Option Bit **01**.



To return to Normal Operation, press and hold indicated button.



While holding button as instructed in last step, press and release indicated button. Display will cycle through all modes while sounding appropriate alarms. Display will then illuminate all display details in a display test.



Display returns to Normal Operation in Dose Mode.

## **PUSH BUTTON PROGRAMMING OF THE PD-10i AND PD-12i ELECTRONIC DOSIMETER**

### **NOTES:**

1. Set Alarm Mode and Idle Mode must be entered from Stay Time Mode unless Stay Time is disabled. In that case (Stay Time disabled), Set Alarm Mode is entered from Dose Rate Mode. If Dose Rate Mode is also disabled, Set Alarm Mode is entered from Dose Mode.
2. Dosimeter must be reset using reset commands before time clock is reset to zero, even though a new Stay Time Alarm threshold is entered.
3. See Table of Option Bit Functions in Manual (A3). Option Bits 08 and 09 are spares and are not accessible.

## APPENDIX C -EXTREMITY PROBE MODELS

### CAUTION

The 4-pin Extremity Probe connectors are of the push/pull variety. Do not twist these connectors while connecting or disconnecting from the PDE-3i™. Align the red dot on the cable connector with the notch on the inside surface of the PDE-3i connector to engage. SAIC recommends that the dosimeter be powered down while the external probe is being connected or disconnected to avoid the possibilities of false counts being accumulated and component damage from the high voltage in-rush current.

The Extremity Probe models operate identically to their internal sensor counterparts with a few exceptions. The Geiger Mueller tube utilized in the extremity probe is an uncompensated type, due to its smaller size. For more information regarding both internal and external sensors, refer to Appendix D, Technical Specifications. The Extremity Probe models will alert the user if the probe is disconnected by sounding an alarm and displaying “n-E”. The only way to acknowledge this alarm is to connect an extremity probe.

Although the extremity cable can be ordered in custom lengths, there is a limit to the length that is a function of GMT dead time and the cable's RC characteristics. For typical values of dead-time and for the cable used, this limit is 20 feet. Cable assemblies beyond this length are subject to foldover at high dose rates.



# **APPENDIX D**

## **TECHNICAL SPECIFICATIONS**



# APPENDIX D - PD-3i™/PD-3i-S™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

|             |                                                                                                          |
|-------------|----------------------------------------------------------------------------------------------------------|
| SIZE:       | 48 mm x 72 mm x 17 mm                                                                                    |
| WEIGHT:     | Less than 90 grams with battery                                                                          |
| RUGGEDNESS: | Exceeds drop test requirements of ANSI N13.27 - 1981<br>(Tested for 40 drops from 1 meter onto concrete) |
| DETECTOR:   | Energy compensated miniature Geiger-Mueller tube                                                         |

## PERFORMANCE CHARACTERISTICS

|                        |                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOSE RANGE:            | 0 $\mu$ R to 999 R                                                                                                                                                                                                                                                                                                                                                       |
| DOSE RESOLUTION:       | < 2 $\mu$ R                                                                                                                                                                                                                                                                                                                                                              |
| DOSE RATE RANGE:       | $\pm 15\%$ or $\pm 20$ $\mu$ R/h from Background to 500 R/h.<br>(Does not include counting statistics which are < $\pm 20\%$ ( $1\sigma$ ) for rates above 10 mR/h)                                                                                                                                                                                                      |
| FOLD OVER:             | No foldover up to 10,000 R/h                                                                                                                                                                                                                                                                                                                                             |
| ENERGY RESPONSE:       | Tissue equivalent to within $\pm 25\%$ from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                                                                                                                    |
| ALARM SETPOINT RANGE:  | Alarms are set with dosimeter pushbuttons or through the PDR-1™ Reader                                                                                                                                                                                                                                                                                                   |
| DOSE:                  | 10 $\mu$ R to 999 R                                                                                                                                                                                                                                                                                                                                                      |
| DOSE WARNING:          | 10 $\mu$ R to 999 R                                                                                                                                                                                                                                                                                                                                                      |
| DOSE RATE:             | 40 $\mu$ R/h to 999 R/h                                                                                                                                                                                                                                                                                                                                                  |
| STAY TIME:             | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                   |
| STAY TIME WARNING:     | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                   |
| VISUAL ALARMS:         | Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                                                                                                                               |
| AUDIO ANNUNCIATOR:     | Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged                                                                                                    |
| DISPLAY:               | Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout ( $\mu$ R, mR, or R units)<br>Low Battery Indicator<br>Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~1.5 $\mu$ R)                                                                                                                         |
| CHIRP:                 | One beep per pre-set dose increment                                                                                                                                                                                                                                                                                                                                      |
| DOSE HISTORY:          | Dose increment setting range: 2 $\mu$ R to 50 mR<br>>200 points (accessible with PDR-1™ Reader)<br>Interval Range: 0 to 109 hours in 6 second increments                                                                                                                                                                                                                 |
| BUILT IN TEST:         | Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                                                                                                                       |
| ACCESS STATUS:         | PDR-1™ toggled flag selects normal data display or the word "Out" (logged out)                                                                                                                                                                                                                                                                                           |
| TAMPER STATUS:         | PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                                                                                                                   |
| SERIAL INTERFACE:      | Bidirectional serial port (accessible via the battery well) for driving remote devices including larger active displays, RS-485 or PLC communication ports, radio transmitters, etc.                                                                                                                                                                                     |
| POWER:                 | Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (normal use):<br>Duracell Alkaline > 2250 hours in 10 mR/h field<br>Battery Life (Idle Mode)<br>Any chemistry – Battery shelf life                                                                                                                                         |
| ENVIRONMENTAL:         | Operating Temperature: -28°C to +60°C<br>Humidity: Up to 95% R.H., non-condensing<br>Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping                                                                                                                                                                                                                  |
| CALIBRATION:           | Factory calibration valid to first of 10 years or 300 R of accumulated exposure. Factory recalibration is available.                                                                                                                                                                                                                                                     |
| USER SET OPTIONS:      | Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in $\mu$ R or mR, Default Rate Reading, Truncation of Fractional mR Dose, Anti-Theft Alarm, Dose History Buffer Organization, Dose initialization on powerup (zero or pre-powerdown value), Idle Mode Disable, Local/Remote Mode Control |
| AVAILABLE ACCESSORIES: | Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels                                                                                                                                                                                                                                                              |

# APPENDIX C - PD-2i™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

|                    |                                                                                                          |
|--------------------|----------------------------------------------------------------------------------------------------------|
| <b>SIZE:</b>       | 48 mm x 72 mm x 17 mm                                                                                    |
| <b>WEIGHT:</b>     | Less than 90 grams with battery                                                                          |
| <b>RUGGEDNESS:</b> | Exceeds drop test requirements of ANSI N13.27 - 1981<br>(Tested for 40 drops from 1 meter onto concrete) |
| <b>DETECTOR:</b>   | Energy compensated miniature Geiger-Mueller tube                                                         |

## PERFORMANCE CHARACTERISTICS

|                               |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOSE RANGE:</b>            | 0 µSv to 9.99 Sv                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>DOSE RESOLUTION:</b>       | < 0.02 µSv                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>DOSE RATE RANGE:</b>       | ±15% or ±0.2 µSv/h from Background to 5 Sv/h.<br>(Does not include counting statistics which are < ±20% (1 $\sigma$ ) for rates above 100 µSv/h)                                                                                                                                                                                                                                                                                     |
| <b>FOLD OVER:</b>             | No foldover up to 100 Sv/h                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>ENERGY RESPONSE:</b>       | Tissue equivalent to within ±25% from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                                                                                                                                                                                      |
| <b>ALARM SETPOINT RANGE:</b>  | Alarms are set through the PDR-1™ Reader                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>DOSE:</b>                  | 0.1 µSv to 9.99 Sv                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>DOSE WARNING:</b>          | 0.1 µSv to 9.99 Sv                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>DOSE RATE:</b>             | 0.4 µSv/h to 9.99 Sv/h                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>STAY TIME:</b>             | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>STAY TIME WARNING:</b>     | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>VISUAL ALARMS:</b>         | Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                                                                                                                                                                                           |
| <b>AUDIO ANNUNCIATOR:</b>     | Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged                                                                                                                                                                |
| <b>DISPLAY:</b>               | Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout (µSv, mSv, or Sv units)<br>Low Battery Indicator<br>Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~0.015 µSv)                                                                                                                                                                                          |
| <b>CHIRP:</b>                 | One beep per pre-set dose increment                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>DOSE HISTORY:</b>          | Dose increment setting range: 0.02 µSv to 0.5 mSv<br>>200 points (accessible with PDR-1™ Reader)                                                                                                                                                                                                                                                                                                                                     |
| <b>INTERVAL RANGE:</b>        | 0 to 109 hours in 6 second increments                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>BUILT IN TEST:</b>         | Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                                                                                                                                                                                   |
| <b>ACCESS STATUS:</b>         | PDR-1™ toggled flag selects normal data display or the word "Out" (logged out)                                                                                                                                                                                                                                                                                                                                                       |
| <b>TAMPER STATUS:</b>         | PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                                                                                                                                                                               |
| <b>SERIAL INTERFACE:</b>      | Bidirectional serial port (accessible via the battery well) for driving remote devices including larger active displays, RS-485 or PLC communication ports, radio transmitters, etc.                                                                                                                                                                                                                                                 |
| <b>POWER:</b>                 | Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (normal use):<br>Duracell Alkaline > 2250 hours in 100 µSv/h field                                                                                                                                                                                                                                                                     |
| <b>ENVIRONMENTAL:</b>         | Battery Life (Idle Mode)<br>Any chemistry – Battery shelf life<br>Operating Temperature: -28°C to +60°C<br>Humidity: Up to 95% R.H., non-condensing                                                                                                                                                                                                                                                                                  |
| <b>CALIBRATION:</b>           | Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping<br>Digital calibration factor set with PDR-1™ Reader. Recommended user calibration interval is two years minimum (factory calibration not required).                                                                                                                                                                                                              |
| <b>USER SET OPTIONS:</b>      | Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, Dose Alarm Acknowledgement, Stay Time Alarm Acknowledgement, 6 second Backlight Hold, Minimum Units in µSv or mSv, Default Rate Reading, Truncation of Fractional mSv Dose, Anti-Theft Alarm, Dose History Buffer Organization, Dose initialization on powerup (zero or pre-powerdown value), Idle Mode Disable, Local/Remote Mode Control. |
| <b>AVAILABLE ACCESSORIES:</b> | Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels                                                                                                                                                                                                                                                                                                                          |

# APPENDIX D - PD-3™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

**SIZE:** 48 mm x 72 mm x 17 mm  
**WEIGHT:** Less than 90 grams with battery  
**RUGGEDNESS:** Exceeds drop test requirements of ANSI N13.27 - 1981  
(Tested for 40 drops from 1 meter onto concrete)  
**DETECTOR:** Energy compensated miniature Geiger-Mueller tube

## PERFORMANCE CHARACTERISTICS

**DOSE RANGE:** 0  $\mu$ R to 999 R  
**DOSE RESOLUTION:** < 2  $\mu$ R  
**DOSE RATE RANGE:**  $\pm 15\%$  or  $\pm 20 \mu$ R/h from Background to 500 R/h.  
(Does not include counting statistics which are <  $\pm 20\%$  ( $1\sigma$ ) for rates above 10 mR/h)  
**FOLD OVER:** No foldover up to 10,000 R/h  
**ENERGY RESPONSE:** Tissue equivalent to within  $\pm 25\%$  from 55 keV to 6 MeV (-70% response at 40 keV)  
**ALARM SETPOINT RANGE:** Alarms are set through the PDR-1™ Reader  
**DOSE:** 10  $\mu$ R to 999 R  
**DOSE WARNING:** 10  $\mu$ R to 999 R  
**DOSE RATE:** 40  $\mu$ R/h to 999 R/h  
**STAY TIME:** 6 seconds to 109 hours  
**STAY TIME WARNING:** 6 seconds to 109 hours  
**VISUAL ALARMS:** Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".  
Low battery voltage indicated by battery icon with at least 24 hours of remaining life.  
**AUDIO ANNUNCIATOR:** Speaker sound level >75 dBA at 30 cm (continuous tone)  
Dose/Warning Alarms: Continuous double/single beat until acknowledged  
Rate Alarm: Continuous beeping while above Rate alarm  
Stay Time/Warning Alarm: Continuous double/single beat until acknowledged  
**DISPLAY:** Liquid Crystal Display (LCD) with push-button controlled backlight  
Autoranging three digit floating point readout ( $\mu$ R, mR, or R units)  
Low Battery Indicator  
Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~1.5  $\mu$ R)  
**CHIRP:** One beep per pre-set dose increment  
Dose increment setting range: 2  $\mu$ R to 50 mR  
**DOSE HISTORY:** >200 points (accessible with PDR-1™ Reader)  
Interval Range: 0 to 109 hours in 6 second increments  
**BUILT IN TEST:** Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.  
**TAMPER STATUS:** PDR-1™ readable flag indicates unauthorized, temporary battery removal  
**POWER:** Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC  
Battery Life (continuous operation):  
Duracell Alkaline > 750 hours in 10 mR/h field  
**ENVIRONMENTAL:** Operating Temperature: -28°C to +60°C  
Humidity: Up to 95% R.H., non-condensing  
Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping  
**CALIBRATION:** Factory calibration valid to first of 10 years or 300 R of accumulated exposure. Factory recalibration is available.  
**USER SET OPTIONS:** Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in  $\mu$ R or mR, Default Rate Reading, Truncation of Fractional mR Dose, Anti-Theft Alarm, Dose History Buffer Organization  
**AVAILABLE ACCESSORIES:** Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels

# APPENDIX C - PD-2™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

|                    |                                                                                                          |
|--------------------|----------------------------------------------------------------------------------------------------------|
| <b>SIZE:</b>       | 48 mm x 72 mm x 17 mm                                                                                    |
| <b>WEIGHT:</b>     | Less than 90 grams with battery                                                                          |
| <b>RUGGEDNESS:</b> | Exceeds drop test requirements of ANSI N13.27 - 1981<br>(Tested for 40 drops from 1 meter onto concrete) |
| <b>DETECTOR:</b>   | Energy compensated miniature Geiger-Mueller tube                                                         |

## PERFORMANCE CHARACTERISTICS

|                               |                                                                                                                                                                                                                                                                                                                               |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOSE RANGE:</b>            | 0 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                                                                         |
| <b>DOSE RESOLUTION:</b>       | < 0.02 $\mu$ Sv                                                                                                                                                                                                                                                                                                               |
| <b>DOSE RATE RANGE:</b>       | $\pm 15\%$ or $\pm 0.2$ $\mu$ Sv/h from Background to 5 Sv/h.<br>(Does not include counting statistics which are $< \pm 20\%$ ( $1\sigma$ ) for rates above 100 $\mu$ Sv/h)                                                                                                                                                   |
| <b>FOLD OVER:</b>             | No foldover up to 100 Sv/h                                                                                                                                                                                                                                                                                                    |
| <b>ENERGY RESPONSE:</b>       | Tissue equivalent to within $\pm 25\%$ from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                                                                         |
| <b>ALARM SETPOINT RANGE:</b>  | Alarms are set through the PDR-1™ Reader                                                                                                                                                                                                                                                                                      |
| <b>DOSE:</b>                  | 0.1 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                                                                       |
| <b>DOSE WARNING:</b>          | 0.1 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                                                                       |
| <b>DOSE RATE:</b>             | 0.4 $\mu$ Sv/h to 9.99 Sv/h                                                                                                                                                                                                                                                                                                   |
| <b>STAY TIME:</b>             | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                        |
| <b>STAY TIME WARNING:</b>     | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                        |
| <b>VISUAL ALARMS:</b>         | Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                                                                                    |
| <b>AUDIO ANNUNCIATOR:</b>     | Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged                                                         |
| <b>DISPLAY:</b>               | Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout ( $\mu$ Sv, mSv, or Sv units)<br>Low Battery Indicator<br>Gamma icon (γ) flashes once per Geiger pulse (~0.015 $\mu$ Sv)                                                                                 |
| <b>CHIRP:</b>                 | One beep per pre-set dose increment                                                                                                                                                                                                                                                                                           |
| <b>DOSE HISTORY:</b>          | Dose increment setting range: 0.02 $\mu$ Sv to 0.5 mSv<br>>200 points (accessible with PDR-1™ Reader)                                                                                                                                                                                                                         |
| <b>BUILT IN TEST:</b>         | Interval Range: 0 to 109 hours in 6 second increments<br>Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                   |
| <b>TAMPER STATUS:</b>         | PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                                                                        |
| <b>POWER:</b>                 | Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (continuous operation):<br>Duracell Alkaline > 750 hours in 100 $\mu$ Sv/h field                                                                                                                                                |
| <b>ENVIRONMENTAL:</b>         | Operating Temperature: -28°C to +60°C<br>Humidity: Up to 95% R.H., non-condensing<br>Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping                                                                                                                                                                       |
| <b>CALIBRATION:</b>           | Digital calibration factor set with PDR-1™ Reader. Recommended user calibration interval is two years minimum (factory calibration not required).                                                                                                                                                                             |
| <b>USER SET OPTIONS:</b>      | Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, Dose Alarm Acknowledgement, Stay Time Alarm Acknowledgement, 6 second Backlight Hold, Minimum Units in $\mu$ Sv or mSv, Default Rate Reading, Truncation of Fractional mSv Dose, Anti-Theft Alarm, Dose History Buffer Organization. |
| <b>AVAILABLE ACCESSORIES:</b> | Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels                                                                                                                                                                                                                   |

# APPENDIX D - PD-10i™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

|             |                                                                                                          |
|-------------|----------------------------------------------------------------------------------------------------------|
| SIZE:       | 48 mm x 72 mm x 17 mm                                                                                    |
| WEIGHT:     | Less than 90 grams with battery                                                                          |
| RUGGEDNESS: | Exceeds drop test requirements of ANSI N13.27 - 1981<br>(Tested for 40 drops from 1 meter onto concrete) |
| DETECTOR:   | Energy compensated miniature Geiger-Mueller tube                                                         |

## PERFORMANCE CHARACTERISTICS

|                        |                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOSE RANGE:            | 0 $\mu$ R to 999 R                                                                                                                                                                                                                                                                                                                                                       |
| DOSE RESOLUTION:       | < 2 $\mu$ R                                                                                                                                                                                                                                                                                                                                                              |
| DOSE RATE RANGE:       | $\pm 15\%$ or $\pm 20 \mu$ R/h from Background to 500 R/h.<br>(Does not include counting statistics which are $< \pm 20\%$ ( $1\sigma$ ) for rates above 10 mR/h)                                                                                                                                                                                                        |
| FOLD OVER:             | No foldover up to 10,000 R/h                                                                                                                                                                                                                                                                                                                                             |
| ENERGY RESPONSE:       | Tissue equivalent to within $\pm 25\%$ from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                                                                                                                    |
| ALARM SETPOINT RANGE:  | Alarms are set with dosimeter pushbuttons or through the PDR-1™ Reader                                                                                                                                                                                                                                                                                                   |
| DOSE:                  | 10 $\mu$ R to 999 R                                                                                                                                                                                                                                                                                                                                                      |
| DOSE WARNING:          | 10 $\mu$ R to 999 R                                                                                                                                                                                                                                                                                                                                                      |
| DOSE RATE:             | 40 $\mu$ R/h to 999 R/h                                                                                                                                                                                                                                                                                                                                                  |
| STAY TIME:             | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                   |
| STAY TIME WARNING:     | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                   |
| VISUAL ALARMS:         | Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                                                                                                                               |
| AUDIO ANNUNCIATOR:     | Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged                                                                                                    |
| DISPLAY:               | Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout ( $\mu$ R, mR, or R units)<br>Low Battery Indicator<br>Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~1.5 $\mu$ R)                                                                                                                         |
| CHIRP:                 | One beep per pre-set dose increment                                                                                                                                                                                                                                                                                                                                      |
| DOSE HISTORY:          | Dose increment setting range: 2 $\mu$ R to 50 mR<br>>200 points (accessible with PDR-1™ Reader)                                                                                                                                                                                                                                                                          |
| BUILT IN TEST:         | Interval Range: 0 to 109 hours in 6 second increments<br>Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                                                              |
| ACCESS STATUS:         | PDR-1™ toggled flag selects normal data display or the word "Out" (logged out)                                                                                                                                                                                                                                                                                           |
| TAMPER STATUS:         | PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                                                                                                                   |
| SERIAL INTERFACE:      | Bidirectional serial port (accessible via the battery well) for driving remote devices including larger active displays, RS-485 or PLC communication ports, radio transmitters, etc.                                                                                                                                                                                     |
| POWER:                 | Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (normal use):<br>Duracell Alkaline > 2250 hours in 10 mR/h field                                                                                                                                                                                                           |
| ENVIRONMENTAL:         | Battery Life (Idle Mode)<br>Any chemistry – Battery shelf life<br>Operating Temperature: -28°C to +60°C                                                                                                                                                                                                                                                                  |
| CALIBRATION:           | Humidity: Up to 95% R.H., non-condensing<br>Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping<br>Factory calibration valid to first of 10 years or 300 R of accumulated exposure. Factory recalibration is available.                                                                                                                                   |
| USER SET OPTIONS:      | Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in $\mu$ R or mR, Default Rate Reading, Truncation of Fractional mR Dose, Anti-Theft Alarm, Dose History Buffer Organization, Dose initialization on powerup (zero or pre-powerdown value), Idle Mode Disable, Local/Remote Mode Control |
| AVAILABLE ACCESSORIES: | Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels                                                                                                                                                                                                                                                              |

# APPENDIX D - PD-12i™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

|             |                                                                                                          |
|-------------|----------------------------------------------------------------------------------------------------------|
| SIZE:       | 48 mm x 72 mm x 17 mm                                                                                    |
| WEIGHT:     | Less than 90 grams with battery                                                                          |
| RUGGEDNESS: | Exceeds drop test requirements of ANSI N13.27 - 1981<br>(Tested for 40 drops from 1 meter onto concrete) |
| DETECTOR:   | Energy compensated miniature Geiger-Mueller tube                                                         |

## PERFORMANCE CHARACTERISTICS

|                        |                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOSE RANGE:            | 0 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                                                                                                                      |
| DOSE RESOLUTION:       | < 0.02 $\mu$ Sv                                                                                                                                                                                                                                                                                                                                                            |
| DOSE RATE RANGE:       | $\pm 15\%$ or $\pm 0.2 \mu$ R/h from Background to 5 Sv/h.<br>(Does not include counting statistics which are < $\pm 20\%$ ( $1\sigma$ ) for rates above 100 $\mu$ Sv/h)                                                                                                                                                                                                   |
| FOLD OVER:             | No foldover up to 100 Sv/h                                                                                                                                                                                                                                                                                                                                                 |
| ENERGY RESPONSE:       | Tissue equivalent to within $\pm 25\%$ from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                                                                                                                      |
| ALARM SETPOINT RANGE:  | Alarms are set with dosimeter pushbuttons or through the PDR-1™ Reader                                                                                                                                                                                                                                                                                                     |
| DOSE:                  | 0.1 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                                                                                                                    |
| DOSE WARNING:          | 0.1 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                                                                                                                    |
| DOSE RATE:             | 0.4 $\mu$ Sv/h to 9.99 Sv/h                                                                                                                                                                                                                                                                                                                                                |
| STAY TIME:             | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                     |
| STAY TIME WARNING:     | 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                                                     |
| VISUAL ALARMS:         | Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                                                                                                                                 |
| AUDIO ANNUNCIATOR:     | Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged                                                                                                      |
| DISPLAY:               | Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout ( $\mu$ Sv, mSv, or Sv units)<br>Low Battery Indicator<br>Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~0.015 $\mu$ Sv)                                                                                                                     |
| CHIRP:                 | One beep per pre-set dose increment                                                                                                                                                                                                                                                                                                                                        |
| DOSE HISTORY:          | Dose increment setting range: 0.02 $\mu$ Sv to 0.5 mSv<br>>200 points (accessible with PDR-1™ Reader)                                                                                                                                                                                                                                                                      |
| BUILT IN TEST:         | Interval Range: 0 to 109 hours in 6 second increments<br>Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                                                                |
| ACCESS STATUS:         | PDR-1™ toggled flag selects normal data display or the word "Out" (logged out)                                                                                                                                                                                                                                                                                             |
| TAMPER STATUS:         | PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                                                                                                                     |
| SERIAL INTERFACE:      | Bidirectional serial port (accessible via the battery well) for driving remote devices including larger active displays, RS-485 or PLC communication ports, radio transmitters, etc.                                                                                                                                                                                       |
| POWER:                 | Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (normal use):<br>Duracell Alkaline > 2250 hours in 100 $\mu$ Sv/h field                                                                                                                                                                                                      |
| ENVIRONMENTAL:         | Battery Life (Idle Mode)<br>Any chemistry – Battery shelf life<br>Operating Temperature: -28°C to +60°C<br>Humidity: Up to 95% R.H., non-condensing                                                                                                                                                                                                                        |
| CALIBRATION:           | Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping<br>Factory calibration valid to first of 10 years or 3 Sv of accumulated exposure. Factory recalibration is available.                                                                                                                                                                                  |
| USER SET OPTIONS:      | Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in $\mu$ Sv or mSv, Default Rate Reading, Truncation of Fractional mR Dose, Anti-Theft Alarm, Dose History Buffer Organization, Dose initialization on powerup (zero or pre-powerdown value), Idle Mode Disable, Local/Remote Mode Control |
| AVAILABLE ACCESSORIES: | Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels                                                                                                                                                                                                                                                                |

# APPENDIX D - PD-10™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

**SIZE:** 48 mm x 72 mm x 17 mm  
**WEIGHT:** Less than 90 grams with battery  
**RUGGEDNESS:** Exceeds drop test requirements of ANSI N13.27 - 1981  
(Tested for 40 drops from 1 meter onto concrete)  
**DETECTOR:** Energy compensated miniature Geiger-Mueller tube

## PERFORMANCE CHARACTERISTICS

**DOSE RANGE:** 0  $\mu$ R to 999 R  
**DOSE RESOLUTION:** < 2  $\mu$ R  
**DOSE RATE RANGE:**  $\pm 15\%$  or  $\pm 20 \mu$ R/h from Background to 500 R/h.  
(Does not include counting statistics which are <  $\pm 20\%$  ( $1\sigma$ ) for rates above 10 mR/h)  
**FOLD OVER:** No foldover up to 10,000 R/h  
**ENERGY RESPONSE:** Tissue equivalent to within  $\pm 25\%$  from 55 keV to 6 MeV (-70% response at 40 keV)  
**ALARM SETPOINT RANGE:** Alarms are set with dosimeter pushbuttons or through the PDR-1™ Reader  
    **DOSE:** 10  $\mu$ R to 999 R  
    **DOSE WARNING:** 10  $\mu$ R to 999 R  
    **DOSE RATE:** 40  $\mu$ R/h to 999 R/h  
    **STAY TIME:** 6 seconds to 109 hours  
    **STAY TIME WARNING:** 6 seconds to 109 hours  
    **VISUAL ALARMS:** Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".  
        Low battery voltage indicated by battery icon with at least 24 hours of remaining life.  
    **AUDIO ANNUNCIATOR:** Speaker sound level >75 dBA at 30 cm (continuous tone)  
        Dose/Warning Alarms: Continuous double/single beat until acknowledged  
        Rate Alarm: Continuous beeping while above Rate alarm  
        Stay Time/Warning Alarm: Continuous double/single beat until acknowledged  
    **DISPLAY:** Liquid Crystal Display (LCD) with push-button controlled backlight  
        Autoranging three digit floating point readout ( $\mu$ R, mR, or R units)  
        Low Battery Indicator  
        Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~1.5  $\mu$ R)  
    **CHIRP:** One beep per pre-set dose increment  
    **DOSE HISTORY:** Dose increment setting range: 2  $\mu$ R to 50 mR  
        >200 points (accessible with PDR-1™ Reader)  
        Interval Range: 0 to 109 hours in 6 second increments  
    **BUILT IN TEST:** Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.  
  
**TAMPER STATUS:** PDR-1™ readable flag indicates unauthorized, temporary battery removal  
  
**POWER:** Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC  
    Battery Life (continuous operation):  
        Duracell Alkaline > 750 hours in 10 mR/h field  
  
**ENVIRONMENTAL:** Operating Temperature: -28°C to +60°C  
    Humidity: Up to 95% R.H., non-condensing  
    Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping  
  
**CALIBRATION:** Factory calibration valid to first of 10 years or 300 R of accumulated exposure. Factory recalibration is available.  
  
**USER SET OPTIONS:** Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in  $\mu$ R or mR, Default Rate Reading, Truncation of Fractional mR Dose, Anti-Theft Alarm, Dose History Buffer Organization  
  
**AVAILABLE ACCESSORIES:** Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels

# APPENDIX D - PD-12™ TECHNICAL SPECIFICATIONS

## PHYSICAL PARAMETERS

|                    |                                                                                                          |
|--------------------|----------------------------------------------------------------------------------------------------------|
| <b>SIZE:</b>       | 48 mm x 72 mm x 17 mm                                                                                    |
| <b>WEIGHT:</b>     | Less than 90 grams with battery                                                                          |
| <b>RUGGEDNESS:</b> | Exceeds drop test requirements of ANSI N13.27 - 1981<br>(Tested for 40 drops from 1 meter onto concrete) |
| <b>DETECTOR:</b>   | Energy compensated miniature Geiger-Mueller tube                                                         |

## PERFORMANCE CHARACTERISTICS

|                               |                                                                                                                                                                                                                                                                       |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOSE RANGE:</b>            | 0 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                                 |
| <b>DOSE RESOLUTION:</b>       | < 0.02 $\mu$ Sv                                                                                                                                                                                                                                                       |
| <b>DOSE RATE RANGE:</b>       | $\pm 15\%$ or $\pm 0.2 \mu$ R/h from Background to 5 Sv/h.<br>(Does not include counting statistics which are < $\pm 20\%$ ( $1\sigma$ ) for rates above 100 $\mu$ Sv/h)                                                                                              |
| <b>FOLD OVER:</b>             | No foldover up to 100 Sv/h                                                                                                                                                                                                                                            |
| <b>ENERGY RESPONSE:</b>       | Tissue equivalent to within $\pm 25\%$ from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                 |
| <b>ALARM SETPOINT RANGE:</b>  | Alarms are set with dosimeter pushbuttons or through the PDR-1™ Reader                                                                                                                                                                                                |
| <b>DOSE:</b>                  | 0.1 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                               |
| <b>DOSE WARNING:</b>          | 0.1 $\mu$ Sv to 9.99 Sv                                                                                                                                                                                                                                               |
| <b>DOSE RATE:</b>             | 0.4 $\mu$ Sv/h to 9.99 Sv/h                                                                                                                                                                                                                                           |
| <b>STAY TIME:</b>             | 6 seconds to 109 hours                                                                                                                                                                                                                                                |
| <b>STAY TIME WARNING:</b>     | 6 seconds to 109 hours                                                                                                                                                                                                                                                |
| <b>VISUAL ALARMS:</b>         | Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                            |
| <b>AUDIO ANNUNCIATOR:</b>     | Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged |
| <b>DISPLAY:</b>               | Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout ( $\mu$ Sv, mSv, or Sv units)<br>Low Battery Indicator<br>Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~0.015 $\mu$ Sv)                |
| <b>CHIRP:</b>                 | One beep per pre-set dose increment                                                                                                                                                                                                                                   |
| <b>DOSE HISTORY:</b>          | Dose increment setting range: 0.02 $\mu$ Sv to 0.5 mSv<br>>200 points (accessible with PDR-1™ Reader)<br>Interval Range: 0 to 109 hours in 6 second increments                                                                                                        |
| <b>BUILT IN TEST:</b>         | Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                    |
| <b>TAMPER STATUS:</b>         | PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                |
| <b>SERIAL INTERFACE:</b>      | Bidirectional serial port (accessible via the battery well) for driving remote devices including larger active displays, RS-485 or PLC communication ports, radio transmitters, etc.                                                                                  |
| <b>POWER:</b>                 | Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (continuous operation):<br>Duracell Alkaline > 750 hours in 100 $\mu$ Sv/h field                                                                                        |
| <b>ENVIRONMENTAL:</b>         | Operating Temperature: -28°C to +60°C<br>Humidity: Up to 95% R.H., non-condensing<br>Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping                                                                                                               |
| <b>CALIBRATION:</b>           | Factory calibration valid to first of 10 years or 3 Sv of accumulated exposure. Factory recalibration is available.                                                                                                                                                   |
| <b>USER SET OPTIONS:</b>      | Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in $\mu$ Sv or mSv, Default Rate Reading, Truncation of Fractional mR Dose, Anti-Theft Alarm, Dose History Buffer Organization        |
| <b>AVAILABLE ACCESSORIES:</b> | Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), and custom front panel labels                                                                                                                                                           |

# APPENDIX D - PERSONAL EXTREMITY MONITORS

## TECHNICAL SPECIFICATIONS

### Models PDE-2i, PDE-3i, PDE-10i and PDE-12i

#### **PHYSICAL PARAMETERS**

##### **CONTROL UNIT**

**SIZE:** 48 mm x 72 mm x 17 mm

**WEIGHT:** Less than 90 grams with battery

**RUGGEDNESS:** Exceeds drop test requirements of ANSI N13.27 - 1981 (Tested for 40 drops from 1 meter onto concrete)

##### **SENSOR**

**DETECTOR:** Geiger-Mueller Tube

**WEIGHT:** 15 grams

**SIZE:** Compensated: 13 mm H x 19 mm W x 40 mm L  
Uncompensated: 10 mm H x 11 mm W x 36 mm L

**CABLE LENGTH:** Standard 5 ft. (Other lengths available on request)

#### **PERFORMANCE CHARACTERISTICS**

**DOSE RANGE:** 0  $\mu$ R to 999 R (PDE-3i, PDE-10i); 0  $\mu$ Sv to 10 Sv (PDE-2i, PDE-12i)

**DOSE RESOLUTION:** < 2  $\mu$ R (< 0.02  $\mu$ Sv)

**DOSE RATE RANGE:**  $\pm 15\%$  or  $\pm 20$   $\mu$ R/h (0.2  $\mu$ Sv/h) from Background to 500 R/h (5 Sv/h)  
[Does not include counting statistics which are <  $\pm 20\%$  ( $1\sigma$ ) for rates above 10 mR/h 100  $\mu$ Sv/h)]

**FOLD OVER:** No foldover up to 10,000 R/h (100 Sv/h)

**ENERGY RESPONSE:** Tissue equivalent to within  $\pm 25\%$  from 55 keV to 6 MeV (-70% response at 40 keV)

**ALARM SETPOINT RANGE:** Alarms are set through the PDR-1™ Reader for all models. PDE-10i and PDE-12i alarms can also be set with the dosimeter pushbuttons.

**DOSE:** 10  $\mu$ R to 999 R (0.1  $\mu$ Sv to 10.0 Sv)

**DOSE WARNING:** 10  $\mu$ R to 999 R (0.1  $\mu$ Sv to 10.0 Sv)

**DOSE RATE:** 40  $\mu$ R/h to 999 R/h (0.4  $\mu$ Sv/h to 10.0 Sv/h)

**STAY TIME:** 6 seconds to 109 hours

**STAY TIME WARNING:** 6 seconds to 109 hours

**VISUAL ALARMS:** Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".

Low battery voltage indicated by battery icon with at least 24 hours of remaining life.

**AUDIO ANNUNCIATOR:** Speaker sound level >75 dBA at 30 cm (continuous tone)

Dose/Warning Alarms: Continuous double/single beat until acknowledged

Rate Alarm: Continuous beeping while above Rate alarm

Stay Time/Warning Alarm: Continuous double/single beat until acknowledged

**DISPLAY:** Liquid Crystal Display (LCD) with push-button controlled backlight

Autoranging three digit floating point readout [ $\mu$ R ( $\mu$ Sv), mR (mSv), or R (Sv) units]

Low Battery Indicator

Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~1.5  $\mu$ R) (~0.015  $\mu$ Sv)

**CHIRP:** One beep per pre-set dose increment

Dose increment setting range: 2  $\mu$ R to 50 mR (0.02  $\mu$ Sv to 0.5 mSv)

**DOSE HISTORY:** >200 points (accessible with PDR-1™ Reader)

Interval Range: 0 to 109 hours in 6 second increments

**BUILT IN TEST:** Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.

**ACCESS STATUS:** PDR-1™ toggled flag selects normal data display or the word "Out" (logged out)

**TAMPER STATUS:** PDR-1™ readable flag indicates unauthorized, temporary battery removal

**SERIAL INTERFACE:** Bidirectional serial port (accessible via the battery well) for driving remote devices including larger active displays, RS-485 or PLC communication ports, radio transmitters, etc.

**POWER:** Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC  
Battery Life (normal use):

Duracell Alkaline > 2250 hours in 10 mR/h (100  $\mu$ Sv/h) field

Battery Life (Idle Mode)

Any chemistry – Battery shelf life

**ENVIRONMENTAL:** Operating Temperature: -28°C to +60°C

Humidity: Up to 95% R.H., non-condensing

Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping

**CALIBRATION:** Digital calibration factor set with PDR-1 Reader. Recommended user calibration interval is two years minimum. (Factory calibration not required.)

**USER SET OPTIONS:** Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, 6 second Backlight Hold, Minimum Units in  $\mu$ R ( $\mu$ Sv) or mR (mSv), Default Rate Reading, Truncation of Fractional mR (mSv) Dose, Anti-Theft Alarm, Dose History Buffer Organization, Dose Warning Alarm, Stay Time Warning Alarm, Idle Mode Disable, Local/Remote Mode Control

**AVAILABLE ACCESSORIES:** Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), custom front panel labels, and  $\beta$ -sensitive end window Geiger Mueller tube extremity monitors.

# APPENDIX D - PERSONAL EXTREMITY MONITORS

## TECHNICAL SPECIFICATIONS

### Models PDE-2™, PDE-3, PDE-10 and PDE-12

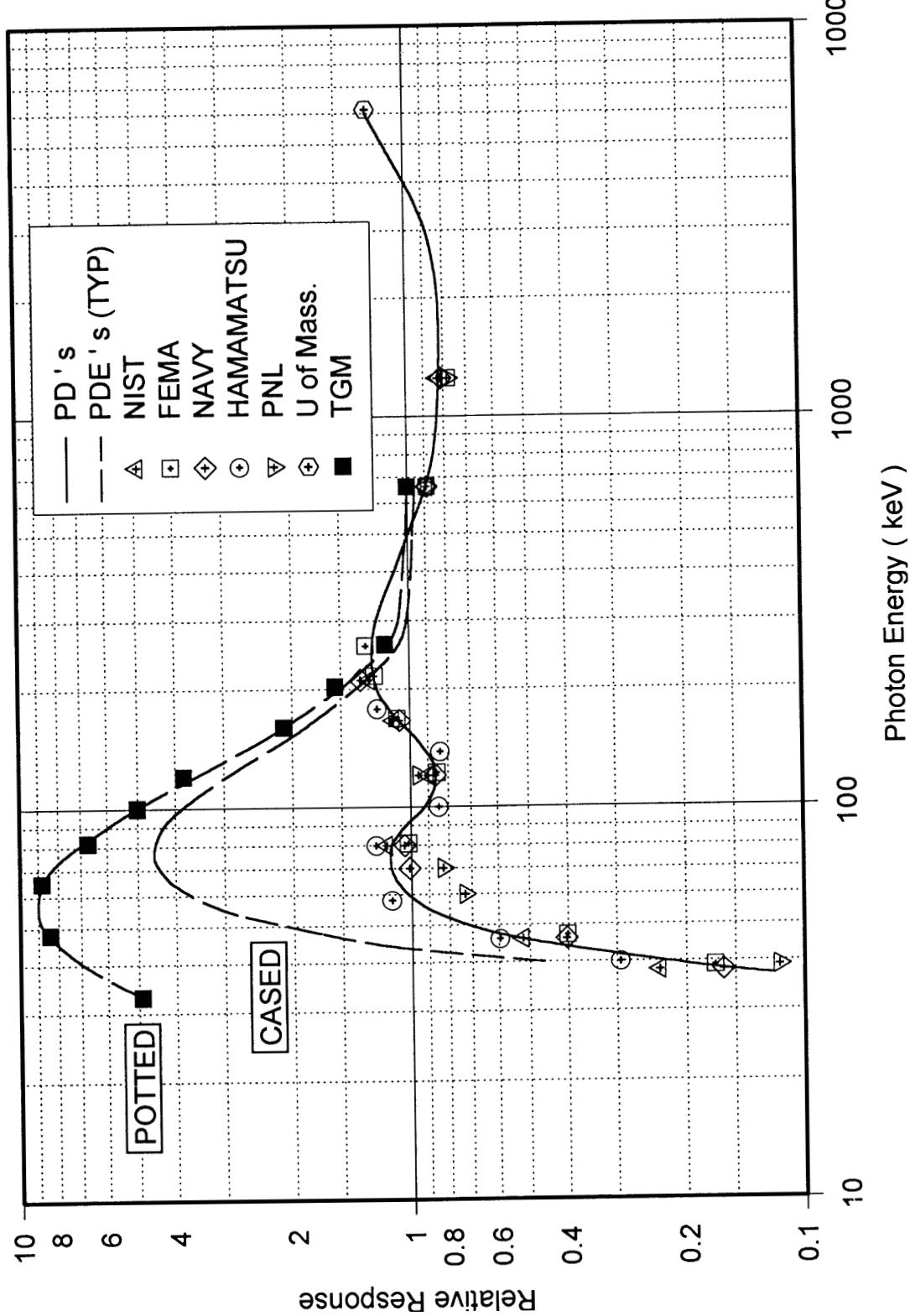
#### PHYSICAL PARAMETERS

| CONTROL UNIT                                                                                                             | SENSOR                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| <b>SIZE:</b> 48 mm x 72 mm x 17 mm                                                                                       | <b>DETECTOR:</b> Geiger-Mueller Tube                                                                |
| <b>WEIGHT:</b> Less than 90 grams with battery                                                                           | <b>WEIGHT:</b> 15 grams                                                                             |
| <b>RUGGEDNESS:</b> Exceeds drop test requirements of ANSI N13.27 - 1981 (Tested for 40 drops from 1 meter onto concrete) | <b>SIZE:</b> Compensated: 13 mm H x 19 mm W x 40 mm L<br>Uncompensated: 10 mm H x 11 mm W x 36 mm L |
|                                                                                                                          | <b>CABLE LENGTH:</b> Standard 5 ft. (Other lengths available on request)                            |

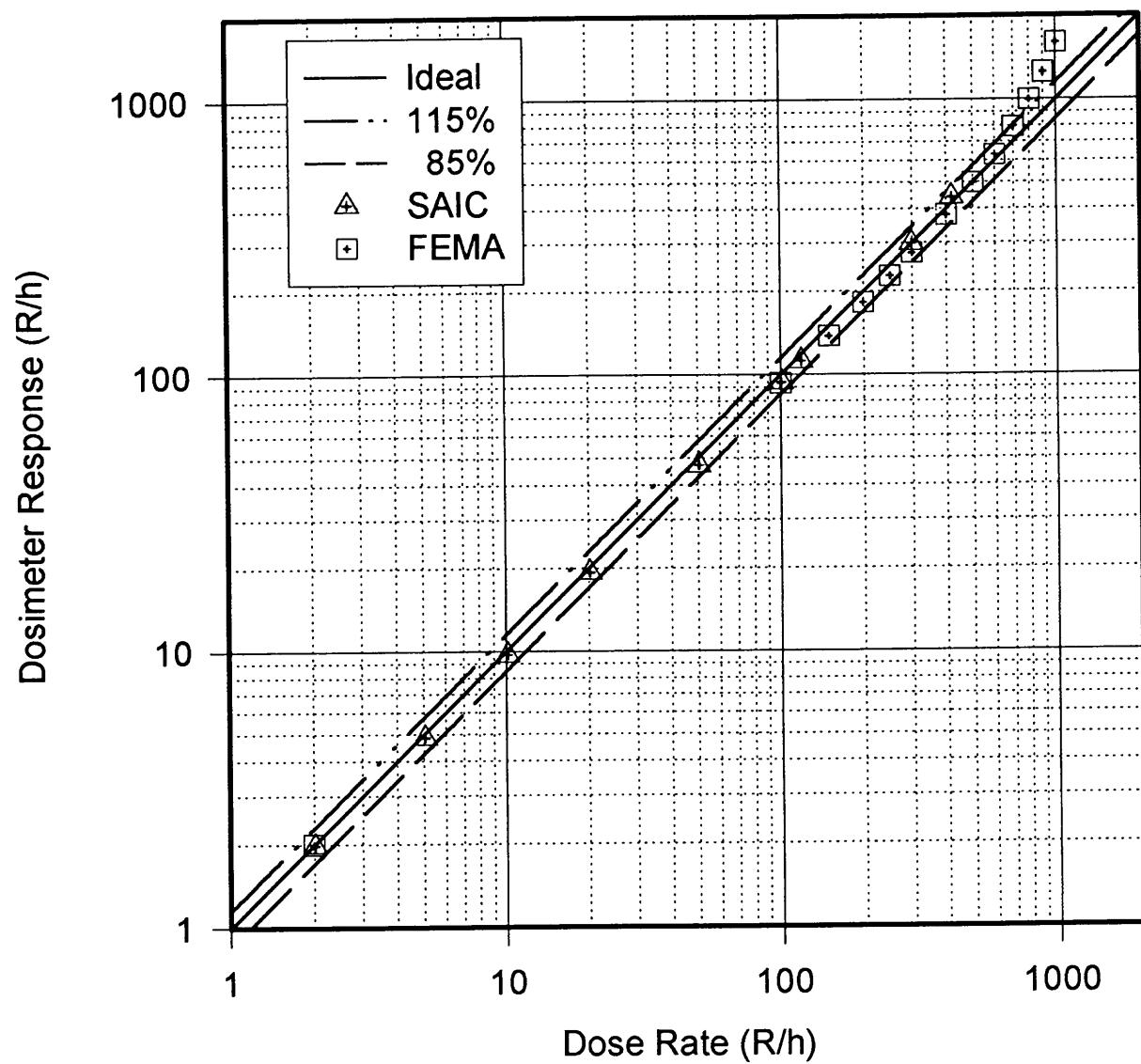
#### PERFORMANCE CHARACTERISTICS

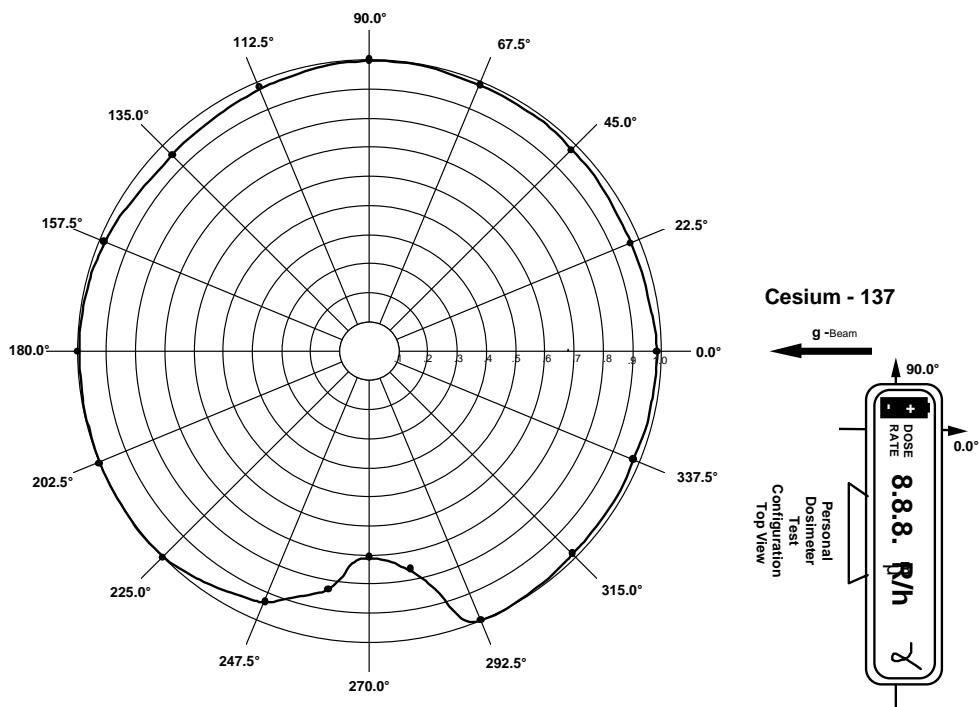
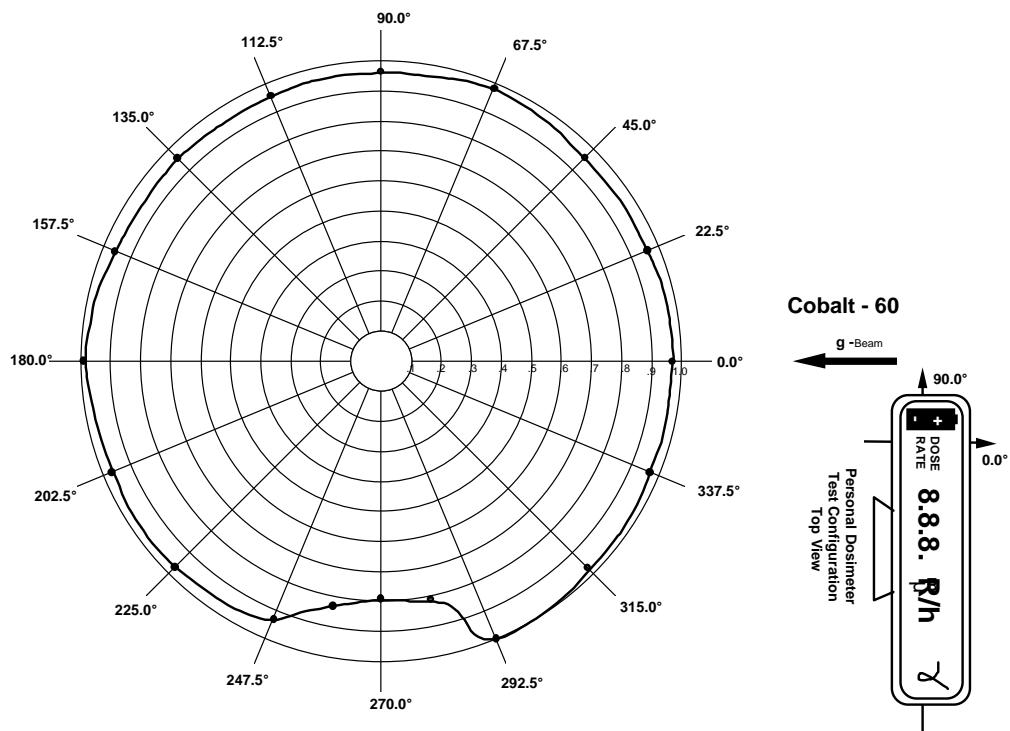
|                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DOSE RANGE:</b> 0 $\mu$ R to 999 R (PDE-3i, PDE-10i); 0 $\mu$ Sv to 10 Sv (PDE-2i, PDE-12i)                                                                                                                                                                                                                                                                       |
| <b>DOSE RESOLUTION:</b> < 2 $\mu$ R (< 0.02 $\mu$ Sv)                                                                                                                                                                                                                                                                                                                |
| <b>DOSE RATE RANGE:</b> $\pm 15\%$ or $\pm 20$ $\mu$ R/h (0.2 $\mu$ Sv/h) from Background to 500 R/h (5 Sv/h)<br>[Does not include counting statistics which are < $\pm 20\%$ ( $1\sigma$ ) for rates above 10 mR/h 100 $\mu$ Sv/h)]                                                                                                                                 |
| <b>FOLD OVER:</b> No foldover up to 10,000 R/h (100 Sv/h)                                                                                                                                                                                                                                                                                                            |
| <b>ENERGY RESPONSE:</b> Tissue equivalent to within $\pm 25\%$ from 55 keV to 6 MeV (-70% response at 40 keV)                                                                                                                                                                                                                                                        |
| <b>ALARM SETPOINT RANGE:</b> Alarms are set through the PDR-1™ Reader for all models. PDE-10i and PDE-12i alarms can also be set with the dosimeter pushbuttons.                                                                                                                                                                                                     |
| <b>DOSE:</b> 10 $\mu$ R to 999 R (0.1 $\mu$ Sv to 10.0 Sv)                                                                                                                                                                                                                                                                                                           |
| <b>DOSE WARNING:</b> 10 $\mu$ R to 999 R (0.1 $\mu$ Sv to 10.0 Sv)                                                                                                                                                                                                                                                                                                   |
| <b>DOSE RATE:</b> 40 $\mu$ R/h to 999 R/h (0.4 $\mu$ Sv/h to 10.0 Sv/h)                                                                                                                                                                                                                                                                                              |
| <b>STAY TIME:</b> 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                             |
| <b>STAY TIME WARNING:</b> 6 seconds to 109 hours                                                                                                                                                                                                                                                                                                                     |
| <b>VISUAL ALARMS:</b> Dose alarm flashes "DOSE"; Dose rate alarm flashes "RATE"; Stay Time shows "m".<br>Low battery voltage indicated by battery icon with at least 24 hours of remaining life.                                                                                                                                                                     |
| <b>AUDIO ANNUNCIATOR:</b> Speaker sound level >75 dBA at 30 cm (continuous tone)<br>Dose/Warning Alarms: Continuous double/single beat until acknowledged<br>Rate Alarm: Continuous beeping while above Rate alarm<br>Stay Time/Warning Alarm: Continuous double/single beat until acknowledged                                                                      |
| <b>DISPLAY:</b> Liquid Crystal Display (LCD) with push-button controlled backlight<br>Autoranging three digit floating point readout [ $\mu$ R ( $\mu$ Sv), mR (mSv), or R (Sv) units]<br>Low Battery Indicator<br>Gamma icon ( $\gamma$ ) flashes once per Geiger pulse (~1.5 $\mu$ R) (~0.015 $\mu$ Sv)                                                            |
| <b>CHIRP:</b> One beep per pre-set dose increment<br>Dose increment setting range: 2 $\mu$ R to 50 mR (0.02 $\mu$ Sv to 0.5 mSv)                                                                                                                                                                                                                                     |
| <b>DOSE HISTORY:</b> >200 points (accessible with PDR-1™ Reader)<br>Interval Range: 0 to 109 hours in 6 second increments                                                                                                                                                                                                                                            |
| <b>BUILT IN TEST:</b> Continuous monitoring of High Voltage Power Supply and GM Tube. Abnormal operation indicated by LCD message and audio annunciator.                                                                                                                                                                                                             |
| <b>TAMPER STATUS:</b> PDR-1™ readable flag indicates unauthorized, temporary battery removal                                                                                                                                                                                                                                                                         |
| <b>POWER:</b> Compatible with any AA size battery with output voltages from 1.25 to 3.6 VDC<br>Battery Life (continuous operation):<br>Duracell Alkaline > 750 hours in 10 mR/h (100 $\mu$ Sv/h) field                                                                                                                                                               |
| <b>ENVIRONMENTAL:</b> Operating Temperature: -28°C to +60°C<br>Humidity: Up to 95% R.H., non-condensing<br>Vibration: Every dosimeter vibrated to > 6 g rms prior to shipping                                                                                                                                                                                        |
| <b>CALIBRATION:</b> Digital calibration factor set with PDR-1 Reader. Recommended user calibration interval is two years minimum. (Factory calibration not required.)                                                                                                                                                                                                |
| <b>USER SET OPTIONS:</b> Rate Display, Rate Audio Alarm, Switch to Rate Display on Rate Alarm, Stay Time Display, Dose Alarm Acknowledgement, Stay Time Acknowledgement, 6 second Backlight Hold, Minimum Units in $\mu$ R ( $\mu$ Sv) or mR (mSv), Default Rate Reading, Truncation of Fractional mR (mSv) Dose, Anti-Theft Alarm, Dose History Buffer Organization |
| <b>AVAILABLE ACCESSORIES:</b> Audio Alarm earpiece or headset, AA-4 Audio Alarm Amplifier (110 dBA output), custom front panel labels, and $\beta$ -sensitive end window Geiger Mueller tube extremity monitors.                                                                                                                                                     |

## Photon Energy Response SAIC PD Dosimeters

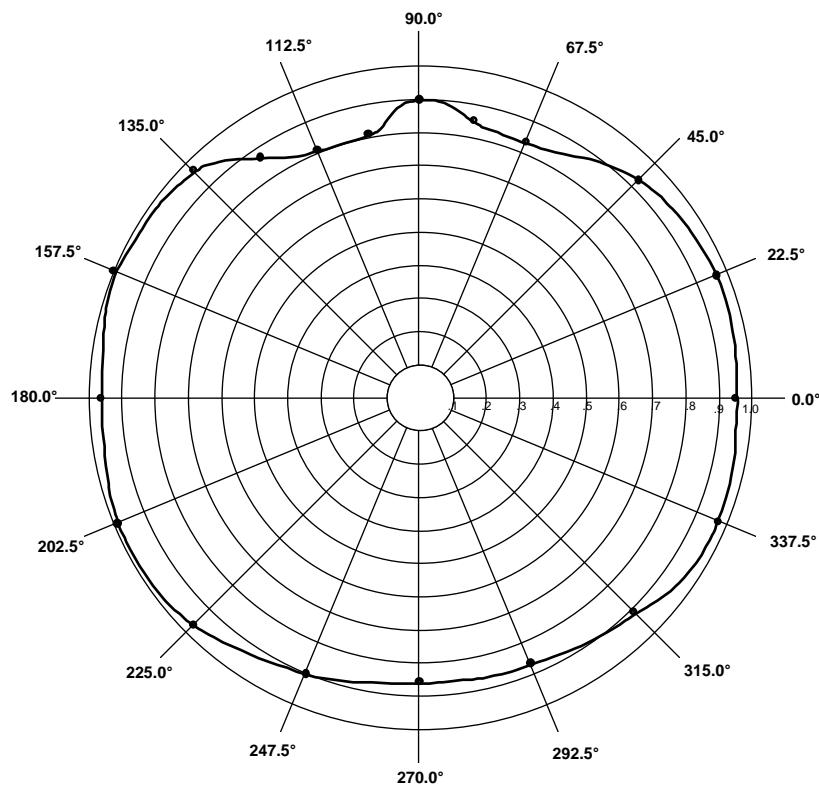


## Rate Linearity SAIC PD Dosimeters

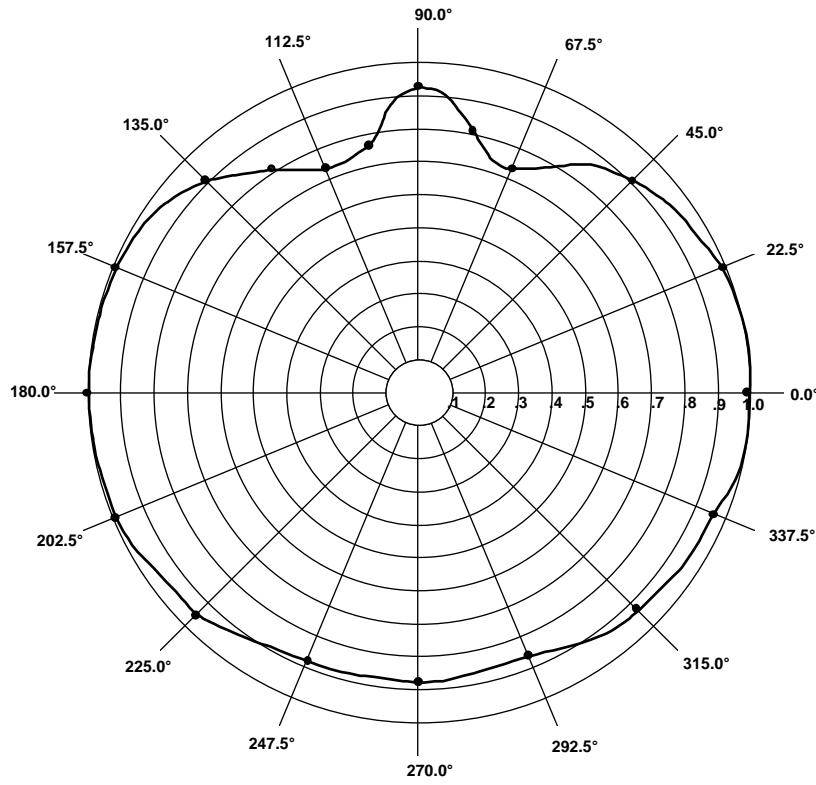
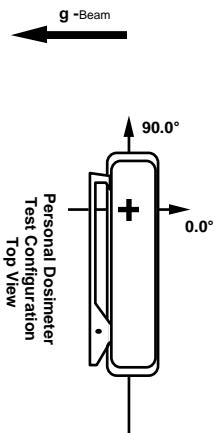




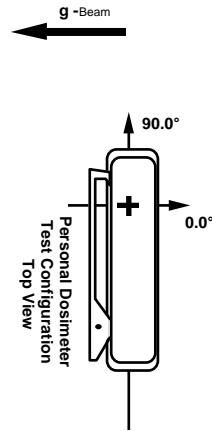
*Isotropism*



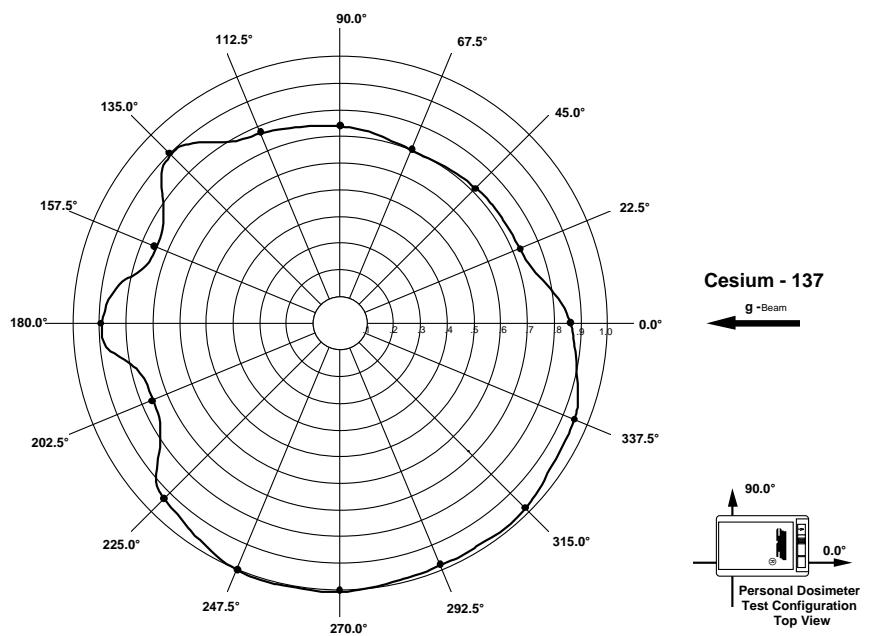
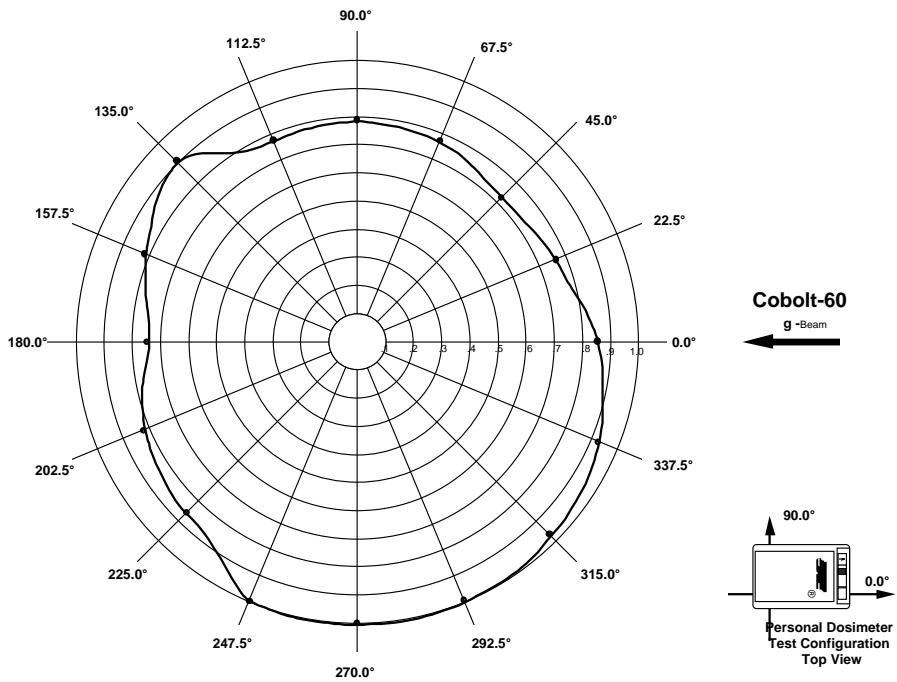
**Cobalt - 60**



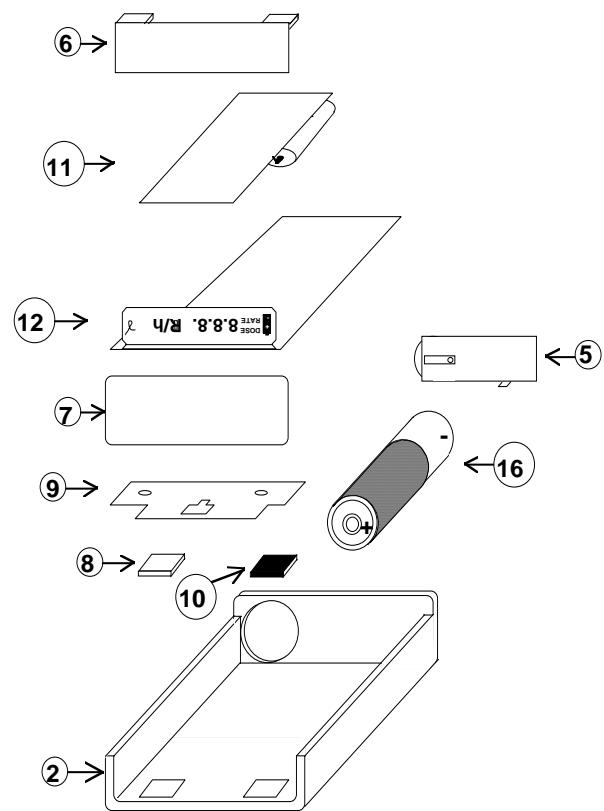
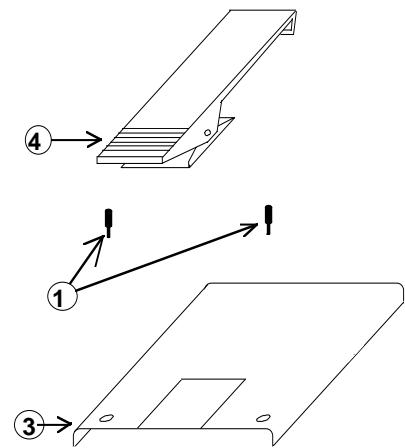
**Cesium - 137**



*Isotropism - Continued*



*Isotropism - Continued*

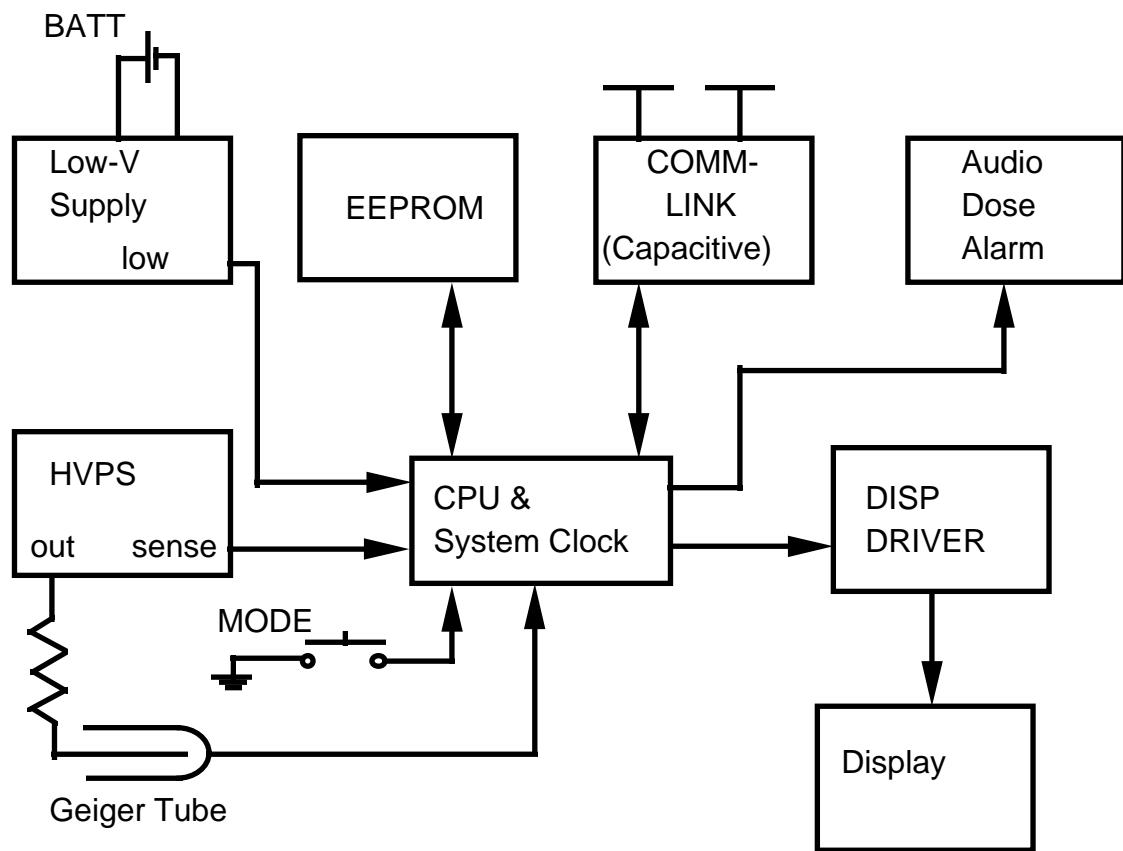


PD-3i Exploded View

## PD-3i Replacement Parts

| ITEM NO. | PART NO. | DESCRIPTION                                      |
|----------|----------|--------------------------------------------------|
| 1        | 1350-152 | Case Screws (2)                                  |
| 2        | 201309   | Front Cover                                      |
| 3        | 201021   | Rear Cover                                       |
| 4        | 201018   | Belt Clip                                        |
| 5        | 2900-26  | Battery Compartment Cover                        |
| 6        | 201022   | Diffuser                                         |
| 7        | 2900-23  | Display Cover                                    |
| 8        | 2900-24  | Mode Button (comes with backlight button)        |
| 9        | 2900-25  | Switch Contact and Gasket                        |
| 10       | 2900-24  | Backlight Button (comes with mode button)        |
| 11       | 201361   | GMT & Power Supply Board ( <i>i</i> -Series)     |
| 11a      | 201301   | GMT & Power Supply Board (non- <i>i</i> -Series) |
| 12       | 201365-1 | Logic Board ( <i>i</i> -Series)                  |
| 12a      | 201305-1 | Logic Board (non- <i>i</i> -Series)              |
| 12b      | 201365-2 | Logic Board ( <i>i</i> -Series) (SI Display)     |
| 12c      | 201305-2 | Logic Board (non- <i>i</i> -Series) (SI Display) |
| 13       | 201313   | Operation & Maintenance Manual                   |
|          | 201023   | Earphone Assembly - Moderate Noise*              |
|          | 201043   | Earphone Assembly - High Noise*                  |
| 16       | MN1500   | Battery - Alkaline                               |
|          | 201125   | Geiger Tube Assembly*                            |
|          | 201010   | Antenna*                                         |

\*Not pictured

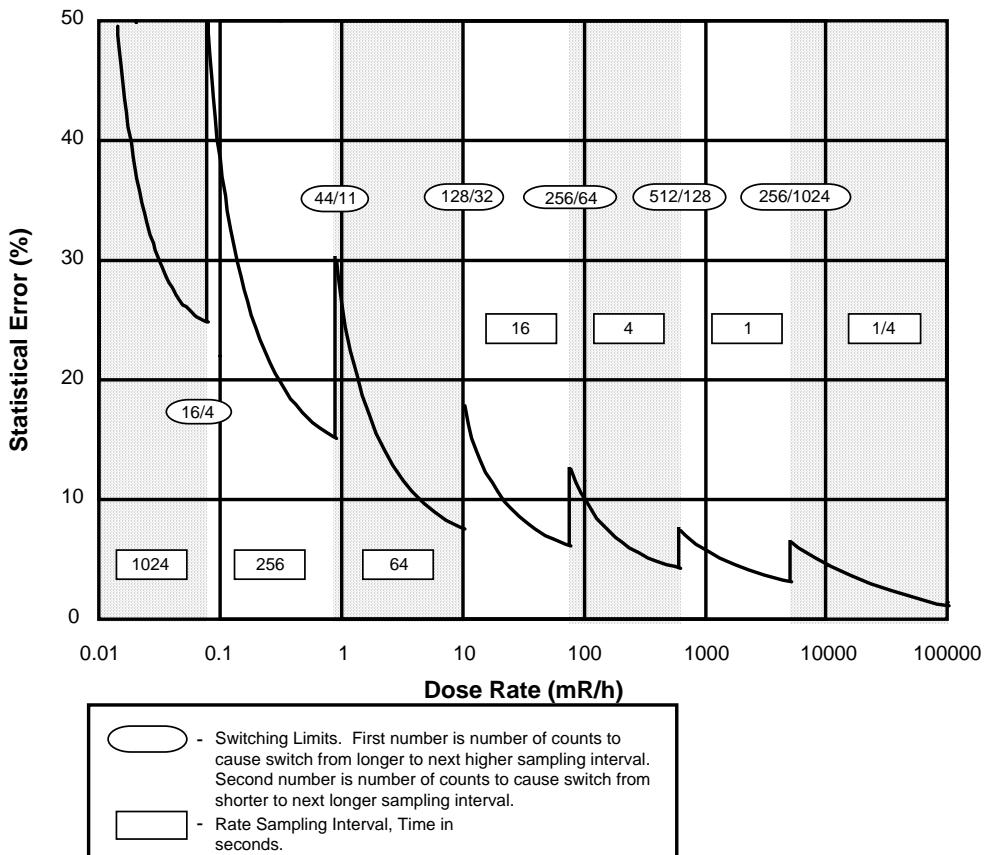


PD-3i Block Diagram

# Dose Rate Mode Calculation

## I. Dose Rate Mode Sampling Intervals

In determining Dose Rate, the PD-3i always seeks to acquire statistically significant data. At lower dose rates, longer sampling periods are used to acquire an accurate reading. At very low dose rates, e.g., background levels, the unit samples for 17 minutes (1024 seconds) to get the most accurate reading. The PD-3i adjusts automatically to provide the appropriate sampling intervals for given dose rates. The statistical error versus Dose Rate is shown in the figure below.



## PD Rate Sampling Intervals

## *II. Dose Rate Sampling Intervals Under Low Rate Fields*

Upon entry to Dose Rate Mode, the unit will display the current dose rate while calculating a new dose rate. After approximately one second, the unit will respond with the current dose rate based upon a 1/4 second sampling interval. If the radiation level is so low that statistically significant data is not accumulated, the PD-3i will increase the sampling interval and provide a new dose rate.

The next sampling interval is one second. Again, if the radiation level is so low that statistically significant data is not accumulated, the sampling interval will increase to four seconds after updating the display with the one second approximation.

The length of the rate sampling interval will continue to increase as the unit attempts to satisfy its internal, statistical criteria until finally, the PD-3i reaches the 1024 seconds or approximately 17 minutes sampling interval.

## *III. Dose Rate Sampling Intervals on Moving from Background to Higher Rate Fields*

The PD-3i is constantly monitoring the number of counts coming from the Geiger-Mueller tube. As a user moves from background levels into a higher rate field, the PD-3i will realize that it is receiving too many counts for the given sampling interval. The PD-3i will compute an approximation of the current rate based on the most recent information and then shorten the sampling period. At the same time, it begins to calculate a more accurate dose rate based on the new sampling period.

As an example, assume the PD-3i has been in a low background area and a 1024 second RSI has just completed. Now the dose rate steps to 10 mR/h where the count rate is 2 cps. After approximately eight seconds, the PD-3i displays 10 mR/h ( $\pm 25\%$ ) and shifts to a 256 second RSI to obtain better statistical accuracy. On the other hand, if the step change in rate occurs within eight seconds of the end of the 1024 second RSI, the PD-3i will, within approximately eight seconds, display 78.1  $\mu$ R/h and switch to the 256 second RSI. After an additional 22 seconds, the PD-3i displays 10 mR/h ( $\pm 15\%$ ) and shifts to a 64 second RSI. Finally, 64 seconds later, the PD-3i again displays 10 mR/h ( $\pm 9\%$ ). This example shows how the accuracy of the first PD-3i rate estimate following a step change in rate depends on the expired RSI fraction at the time of the step change. However, second and subsequent estimates will be accurate within statistical limits.

## *IV. Dose Rate Measured by the Chirper or Gamma Icon*

Another way to measure dose rate is by setting the dose chirp to a relatively low value, such as 10  $\mu$ R. In a field of 10 mR/h, the unit will chirp about every four seconds. Dose rate is also indicated visually by the flashing Gamma icon. The Gamma

icon flashes with each GM tube pulse or approximately every 1.5  $\mu$ R. The calibration factor is the actual  $\mu$ R/cnt for a specific PD-3i dosimeter. In a field of 10 mR/h or higher, the icon will stay on constantly.

Note that there is a limit to the frequency at which a PD-3i can generate a chirp. Chirp rate is not linear with dose rate under high dose rate and low chirp increment conditions. Refer to Section 2.2.7 for a detailed description of Chirp Mode.

Pressing the Mode button will exit the Dose Rate Mode and enter the Stay-Time Mode (if Stay-Time Display Mode is enabled).

#### *V. Dead Time Correction*

The PD-3i implements software to correct RATE for dead-time losses at very high dose rates. The correction is made via a factory adjustment which is valid for the life of the instrument. It is an exact implementation of the simple Dead-Time Correction:

$$R_t = R_m / (1 - R_m \tau) .$$

The associated true dose-Increment is given by

$$\delta D_t = \delta D_m / (1 - R_m \tau) = \delta D_m \times (1 + R_t \tau) = \delta D_m + \delta D_{dt} ,$$

where sub-t, sub-m and sub-dt denote “true”, “measured” and “dead-time”; R=RATE, D=DOSE, and  $\tau$ =Dead-time/count. The last form is especially useful because  $\delta D_m$  is the uncorrected increment which automatically goes into the dose accumulator, so  $\delta D_{dt} = \delta D_m R_t \tau$  is the correction which must be added.

# APPENDIX E - PD FAMILY RELATED EQUIPMENT

## E.1 Readers

### *E.1.1 PDR-1™ Personal Dosimeter Reader*

The PDR-1 Personal Dosimeter Reader provides the interface between the PD Series of Personal Dosimeters and computer via an RS-232 connection. The PDR-1 also includes a Manual Dose Reset button.

### *E.1.2 PDR-1/S Personal Dosimeter Reader with Check Source*

The PDR-1/S Personal Dosimeter Reader with Check Source is identical to the PDR-1 with the addition of an internal check source. The radioactive check source is microprocessor controlled. When using the check source, the PD Series Personal Dosimeter is exposed to sufficient dose to provide confirmation of operability immediately before the user enters a work area.

## E.2 RadStar™ Radio Transmission Dosimetry

The RadStar System provides the latest in Radio Transmission Dosimetry. With its two-way communication, RadStar provides the most robust and reliable real-time monitoring capability available today. The system is composed of the PD-4 Dosimeter, the PDE-4 Extremity Monitor with up to four extremities and whole body monitored simultaneously, the PDX-4 RadBase, and a base PC computer.

### *E.2.1 PD-4™*

The PD-4 transmitting and receiving alarming dosimeter sends dose information and receives set points and remote alarms from a central observation location through a robust communications link.

### *E.2.2 PDE-4™*

Like the PD-4, the PDE-4 transceiving extremity monitor sends dose information and receives set points and remote alarms for whole body. However, the PDE-4 can add up to four extremity sensors to monitor head, arms, fingers, feet, or other points. Compensated and uncompensated GM tubes are available for sensors.

### *E.2.3 PDX-4™*

The PDX-4 receives and transmits data from multiple PD-4 dosimeters and PDE-4 extremity monitors. With its two-way communications capability, alarms can be reset to provide real-time ALARA control. The PDX-4 provides real-time information for display and processing by a personal computer.

## **E.3 Headsets**

### *E.3.1 Headsets for Alarming Dosimeter/Extremity Monitor*

Two Headsets provide a means of hearing alarms from any PD Series Personal Dosimeters under medium and high-noise conditions. A rugged, flexible boot placed over the dosimeter provides attachment for an acoustically coupled headset.

For medium noise environments, the 201023 Earphone uses an earpiece which allows for near normal hearing to occur. For high-noise environments, the 201043 Earphone provides sound protection in addition to the acoustic coupling to the dosimeter.

## **E.4 Alarm Amplifier**

### *E.4.1 AA-4 Alarm Amplifier*

The AA-4 Alarm Amplifier provides a means of hearing alarms from any PD Series Personal Dosimeter under high noise conditions. The AA-4 is worn at the waist and connects to the dosimeter via flexible boot and a short length of tubing. The sound output is a minimum 110 dBA @ 20 cm continuous tone.



# APPENDIX F - CALIBRATION

## PD-3i™ Calibration with SAICs PDRC3 Software Demo

### F.1 PDRC3

PDRC3 is a software application which runs on IBM PC or compatible computers. It provides a user interface for operations involving a PDR-1 Reader. PDRC3 allows for alarm adjustment, option setting and calibration of PD-3i Dosimeters. In addition, it can be used to set the time and date values in the PDR-1 Reader.

To invoke PDRC3, first enter the directory or drive which contains the program. Type “PDRC3” at the command line. The first screen that appears is the title screen, which also indicates the version number of PDRC3. Hit the ENTER key and the second screen will indicate if a PDR-1 Reader could be located at either COM1 or COM2. It will also show the current time and date as read from the PDR-1, and the firmware revision of the PDR-1 Reader. Hit the ENTER key once again and the Main Menu will appear. For details on PDRC3 operation, choose the Help option.

### F.2 Overview

The PD-3i contains three factors, stored in EEPROM, which determine the dose and dose rate readings. Two of these are factory adjustments that are good for the life of the GM tube. One is Dead Time Correction, which adjusts for dead-time losses at very high dose rates. The second is Background Correction, which accounts for spurious counts generated by the GM tube. This latter factor affects only very low dose rate readings.

The Linear Dose Calibration Factor (Dose Cal) provides the actual calibration of the PD-3i. This factor is initially set at the factory. SAIC recommends that calibration be performed every two years. The only requirements for PD-3i calibration are a calibration system capable of at least 10 mR/h, a PDR-1 Reader, computer set-up and application software such as PDRC3.

### F.3 Calibration Procedure

*F.3.1* Assemble all units to be calibrated and start PDRC3. The calibration routines are password protected. Select the Lock option and enter the correct password. PDRC3 is shipped with a factory default password of “SAIC”.

*F.3.2* Send the Dose Reset command to each dosimeter by selecting option R, or by pressing the Dose Reset button on the PDR-1.

*F.3.3* Expose each dosimeter to an integrated dose of at least 10 mR (SAIC recommends using 100 mR). All units should be exposed to the same dose.

*F.3.4* Choose the Setup Option in PDRC3 and enter the actual exposed dose when prompted for Current Default Linear Calibration Dose. Hard copy reporting of calibration data can be enabled or disabled in the Setup option.

*F.3.5* Place one of the exposed dosimeters on the PDR-1 and choose the “M” option. Enter the actual exposed dose. The EEPROM contents will be displayed. At this point, the last calibration date, zero time, current dose, etc., can be double checked.

*F.3.6* Hit ENTER and the new Dose Cal factor will be displayed. If the new factor is within the range considered to be valid, then it may be written to EEPROM by striking any key besides ESC. If the new Dose Cal factor is not within range, an error message will be displayed and updating EEPROM will not be allowed. Hit ENTER to return to the Main Menu.

*F.3.7* Repeat Steps F.3.5 through F.3.6 for each dosimeter to be calibrated.

#### **F.4 Repair Notes**

If a unit fails calibration due to a Dose Cal factor out of range, this is an indication of either a problem encountered in the calibration procedure, or a failed component. The calibration should be repeated to eliminate the first possibility. If component failure is suspected, the unit should be sent to an on-site technician or returned to the factory for repair.

Replacement of certain electronic components can affect calibration. In general, the PD-3i should be calibrated following the replacement of any electronic components. Replacement of the GM tube or any components in the cathode pulse coupling circuit can also affect the Dead Time and Background Correction factory adjustments. If these repairs are made on site, contact SAIC for details on performing these adjustments.

## APPENDIX G - EEPROM MAPPING

### PD-3i™ EEPROM MAP

Non-volatile data storage in the PD-3i is provided by a 256 register (2 bytes per register) serial EEPROM (93C66). The allocation is as follows where the bit notation, Option1!/Option0, means that Option1 is effective if the bit is set and Option0 is effective if the bit is clear:

| Register  | Format | Contents                                                                                                                                                                                        |
|-----------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 000 (00H) | D      | Date of most recent reset operation                                                                                                                                                             |
| 001 (01H) | T      | Time of most recent reset operation                                                                                                                                                             |
| 002 (02H) | N      | User ID (most significant word)                                                                                                                                                                 |
| 003 (03H) | N      | User ID (least significant word)                                                                                                                                                                |
| 004 (04H) | b      | User selectable option bits                                                                                                                                                                     |
|           |        | 1st Byte:                                                                                                                                                                                       |
|           |        | b0: Enable!/Disable Rate Mode                                                                                                                                                                   |
|           |        | b1: Enable!/Disable Audio Rate Alarm                                                                                                                                                            |
|           |        | b2: Enable!/Disable automatic change to Rate<br>Display Mode when the measured dose rate<br>exceeds the Rate Alarm level                                                                        |
|           |        | b3: Enable!/Disable Stay Mode                                                                                                                                                                   |
|           |        | b4: Enable!/Disable Mode Pushbutton<br>acknowledgement of audio Dose Alarm                                                                                                                      |
|           |        | b5: Enable!/Disable Mode Pushbutton<br>acknowledgement of audio Stay-Time Alarm                                                                                                                 |
|           |        | b6: Enable!/Disable Automatic Shutdown after Low<br>Battery Voltage Detect                                                                                                                      |
|           |        | b7: Enable!/Disable 6 s hold time for Backlight                                                                                                                                                 |
|           |        | 2nd Byte:                                                                                                                                                                                       |
|           |        | b0: $\mu\text{R}/(\text{h})/!\text{mR}/(\text{h})$ is the smallest displayed<br>radiation unit                                                                                                  |
|           |        | b1: $(20.0 \mu\text{R}/\text{h})/!(0.00 \mu\text{R}/\text{h})$ is the displayed dose<br>rate following a 256 or 1024 s rate sampling<br>interval during which no GMT counts were<br>accumulated |
|           |        | b2-b6: Spare option bits                                                                                                                                                                        |
|           |        | b7: DATA/!“Out” on LCD for access control ( <i>i</i> -<br>Series only)                                                                                                                          |
| 005 (05H) | F      | Dose pre-alarm level in GMT counts                                                                                                                                                              |
| 006 (06H) | F      | Dose alarm level in GMT counts                                                                                                                                                                  |
| 007 (07H) | F      | Rate alarm level in GMT counts per 1024 s                                                                                                                                                       |
| 008 (08H) | I      | Dose increment per chirp in GMT counts                                                                                                                                                          |

|                                                                                                                  |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 009 (09H)                                                                                                        | I   | Time increment per dose history point in 0.1 minute units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 010 (0AH)                                                                                                        | I   | Stay pre-alarm time in tenth minutes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 011 (0BH)                                                                                                        | I   | Stay alarm time in tenth minutes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 012 (0CH)                                                                                                        | I   | Time to automatic shutdown after low battery voltage detect in tenth minutes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 013 (0DH)                                                                                                        | I   | Time to display disable after most recent J-6389/PD transaction in tenth minutes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 014 (0EH)                                                                                                        | B,B | Failed GMT resolution time (in 1024 s units). The 2nd byte is spared.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 015 (0FH)                                                                                                        |     | Backlight hold time in 0.1 minute (6s) units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| —                                                                                                                | —   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| —                                                                                                                | —   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 021 (15H)                                                                                                        |     | Spare register                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 022 (16H)                                                                                                        | D   | Date of most recent calibration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 023 (17H)                                                                                                        | T   | Time of most recent calibration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 024 (18H)                                                                                                        | B,b | 1st byte is background correction rate in GMT counts per 1024 s, 2nd byte is calibration related option bits <ul style="list-style-type: none"> <li>b0: Preserve/!Truncate fractional mR(/h) display values</li> <li>b1: Circular/!Linear Dose history buffer (DHBF_F)</li> <li>b2: Enable/!Disable Auto-Shutdown feature after most recent J-6389/PD transaction (Lost Timer)</li> <li>b3: Serial/!MODE Pushbutton Control</li> <li>b4: Enable/!Disable Global Audio</li> <li>b5: Enable/!Disable ability to enter Idle Mode</li> <li>b6: Enable/Disable RAM initialization from EEPROM on Power up</li> <li>b7: (R/h)/!(R/m) dose rate display units (PD-3 needs a modified display to utilize this feature)</li> </ul> |
| <i>b3 - b7 for non-i-Series:</i>                                                                                 |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| b3: Spare bit                                                                                                    |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| b4: (R/h)/!(R/m) dose rate display units (PD-3 needs a modified display to utilize this feature)                 |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| b5: Mode-Pushbutton/!Serial Control (presently this is just a hook for future addition of serial remote control) |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| b6-b7: Spare bits                                                                                                |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

|           |   |                                                                                                                                          |
|-----------|---|------------------------------------------------------------------------------------------------------------------------------------------|
| 025 (19H) | F | Dose conversion factor (linear calibration factor) in $\mu$ R per GMT count (DSCF)                                                       |
| 026 (1AH) | F | GMT dead time correction factor in seconds per GMT count divided by 1024                                                                 |
| 027 (1BH) | I | Sum of all rate sampling intervals since most recent reset during which the measured rate exceeded the rate alarm level in tenth minutes |
| 028 (1CH) | F | Total accumulated dose since most recent reset in GMT counts (DOSE)                                                                      |
| 029 (1DH) | F | Peak dose rate value measured since most recent reset in GMT counts per 1024 s                                                           |
| 030 (1EH) | A | ASCII prefix of Factory Serial Number                                                                                                    |
| 031 (1FH) | I | Numerical suffix of Factory Serial Number                                                                                                |
| 032 (20H) | F | Start of Dose History Buffer in GMT counts                                                                                               |
| —         | — |                                                                                                                                          |
| —         | — |                                                                                                                                          |
| 255 (FFH) | F | End of Dose History Buffer in GMT counts                                                                                                 |

Formats:

D-format

| 1 st byte |   |   |   |   |   |   |   | 2 nd byte |   |   |   |   |   |   |   |
|-----------|---|---|---|---|---|---|---|-----------|---|---|---|---|---|---|---|
| m         | m | m | m | d | d | d | d | d         | y | y | y | y | y | y | y |
|           |   |   |   |   |   |   |   |           |   |   |   |   |   |   |   |

1≤mmmm=M1\_mmmm=Month≤12  
1≤dddd=Day≤31  
0≤yyyyyy=Year≤99

Example: 04/23/90 = 4BDAH

T-format

| 1 st byte |   |   |   |   |   |   |   | 2 nd byte |   |   |   |   |   |   |   |
|-----------|---|---|---|---|---|---|---|-----------|---|---|---|---|---|---|---|
| h         | h | h | h | h | m | m | m | m         | m | m | s | s | s | s | s |
|           |   |   |   |   |   |   |   |           |   |   |   |   |   |   |   |

0≤hhhh=Hour≤23  
0≤mmmmmm=Minute≤59  
0≤ssss=Second/2≤29

Example: 15:47:20 = 7DEAH

N-format

Not formatted. The user may enter any type of data in these registers such as ASCII or BCD.

### b-format

Bit format means that each bit of the register (or half register) is interpreted as an individual option bit.

### F-format

Floating point (hexadecimal). The 1st byte contains the signed exponent and most significant digit of the unsigned mantissa and the 2nd byte contains the two least significant mantissa digits.

Example 1:  $43ABH = 3.ABx16^4 = (3+10/16+11/256)x65536 = 240384$ .

Example 2:  $95DCH = 5.DCx16^{(-7)} = (5+13/16+12/256)/16^7 = 2.18x10^{(-8)}$ .

### I-format

Integer (unsigned hexadecimal, 1st byte is the most significant).

Example:  $123EH = 1x16^3 + 2x16^2 + 3x16^1 + 14x16^0 = 4670$ .

### B-format

Byte (unsigned hexadecimal). Example:  $32H = 3x16^1 + 2x16^0 = 50$ .

### A-format

Standard ASCII character codes. Example:  $5845H = "XE"$ .

Dose and dose rate values in  $\mu R$  and  $\mu R/h$  are obtained through multiplication by the appropriate conversion factor. Specifically, to convert a dose in GMT counts to  $\mu R$ , multiply by the linear calibration factor; to convert a dose rate in GMT counts per 1024 s to  $\mu R/h$ , multiply first by the linear calibration factor and then by the constant, 3600/1024.

## Dose History Registers — 32 to 255 (\$20 to \$FF)

As seen from the memory map, the first 32 Registers of the Serial EEPROM are used to store operating parameters such as calibration factors, user option flags, and the factory serial number. The remaining 224 registers (2 bytes each) are available for the storage of Dose History Data which is written into the EEPROM in F format. The stored values are in units of counts which must be multiplied by DSCF, the dose conversion factor, in order to obtain  $\mu R$  units.

The 224 word Dose History Buffer (DHB) may be arranged either as a circular buffer (DHBF\_F=1) or as a single pass, linear buffer (DHBF\_F=0). In either case, the current value of DOSE is written into the DHB at regular intervals determined by the EEPROM constant, E\_INDH. If the linear buffer option is chosen, the writing of Dose History Data is terminated after the 223rd register is written. Otherwise, old data is overwritten such that the DHB always contains the most recent Dose History Data. After writing a new DOSE value into the DHB, the PD-3i<sup>TM</sup> writes a set of End-Of Buffer bytes (EOBs=\$FAFA) into the next available EEPROM word (i.e., the PD-3i<sup>TM</sup> shoves the EOBs ahead of the newest data).

If the PD-3i loses power momentarily, it finds its place during Powerup Reset by scanning the entire 224 word DHB for the EOBs. When found, the EOBs are overwritten with a set of Beginning-of-Buffer bytes (BOBs=\$F5F5) and the EOBs are written into the next available EEPROM word. If, during Powerup Reset, the PD-3i cannot find the EOBs, it writes the BOBs into REG32 and the EOBs into REG33. In general, this should only occur once at the factory when the unit is initially powered up. Here are a few examples.

Newly initialized EEPROM (starting at REG32):

\$F5F5 \$FAFA \$FFFF \$FFFF ...

Two dose history intervals later:

\$F5F5 \$0500 \$0A00 \$FAFA \$FFFF \$FFFF ...

After momentary interruption of power:

\$F5F5 \$0500 \$0A00 \$F5F5 \$FAFA \$FFFF \$FFFF ...

After two more dose history intervals:

\$F5F5 \$0500 \$0A00 \$F5F5 \$0300 \$0700 \$FAFA \$FFFF ...

With the circular buffer configuration, BOBs are overwritten just like old DOSE data after the dose history pointer wraps around from REG255 to REG32. With the linear configuration, the Dose History function is disabled when the buffer becomes full (i.e., when the EOBs are written into REG255) and the PD-3i must be reset to restore dose history capability (RESET causes the dose history pointer to be re-initialized to REG32 with the linear configuration).